



## Comparison of Stability of the Results of Orthodontic Treatment and Gingival Health between Hawley and Vacuum-formed Retainers

<sup>1</sup>Seyed H Moslemzadeh, <sup>2</sup>Aydin Sohrabi, <sup>3</sup>Ali Rafighi, <sup>4</sup>Somaieh Farshidnia

### ABSTRACT

**Aim:** Retention is one of the stages of orthodontic treatment, which is an attempt to retain teeth in their corrected positions after active treatment with the use of fixed orthodontic appliances. The aim of the present study was to compare the stability of the results of orthodontic treatment and the gingival health between Hawley retainer (HR) and vacuum-formed retainer (VFR) with two different thicknesses.

**Materials and methods:** In this randomized clinical trial, 66 patients undergoing comprehensive orthodontic treatment in a private office were evaluated after completion of treatment. The subjects were randomly assigned to three groups. At the end of orthodontic treatment, the subjects in all the groups received a fixed bonded retainer in the mandible; in the maxilla, group I received an HR, group II received a VFR with a thickness of 1.5 mm, and group III received a VFR with a thickness of 1 mm. The American Board of Orthodontics objective grading system (ABO-OGS) index was used at the end of treatment (before the delivery of the retainers) and 6 months after the use of retainers to evaluate the stability of the results of orthodontic treatment. Gingival index (GI) was used at the two above-mentioned intervals to evaluate gingival health. The ABO-OGS measurements were carried out on dental casts by a clinician who was blinded to the types of retainers the patients wore. Data were analyzed with Statistical Package for the Social Sciences (SPSS) version 20, using proper statistical analyses.

**Results:** Six months after the delivery of retainers, ABO-OGS and GI scores with the 1.5 mm VFR were higher than those in the two other groups, with no significant differences between the three groups. There were no significant differences between the ABO-OGS scores before the delivery of retainers and 6 months after the use of retainers in any of the study groups. In the HR

and 1.5 mm VFR groups, there were significant differences in GI scores between the period before the delivery of the retainers and 6 months after their delivery; however, in the 1 mm VFR group, no significant differences were observed in GI scores between the two time intervals.

**Conclusion:** Hawley retainer and 1 mm thick and 1.5 mm thick VFRs were equally effective in preserving and stabilizing the results of orthodontic treatment during the 6-month interval after the completion of orthodontic treatment. In addition, there were no significant differences between the three retainers in relation to gingival health.

**Clinical significance:** The VFR might be a good alternative for HR due to its better esthetic appearance and greater popularity with orthodontic patients.

**Keywords:** American Board of Orthodontics model grading system, American Board of Orthodontics objective grading system, Gingival index, Hawley retainers, Vacuum-formed retainers.

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### INTRODUCTION

Relapse in orthodontics is defined as any change in the position of teeth and arch relationship during the early stages after completion of orthodontic treatment.<sup>1</sup> Retention is a stage of orthodontic treatment, during which an attempt is made to preserve teeth in their corrected position after active orthodontic treatment with fixed orthodontic appliances.<sup>2,3</sup> To this end, HR has been the most commonly used retainer to-date.<sup>4</sup> Vacuum-formed retainers are removable retainers made of transparent

<sup>1-4</sup>Department of Orthodontics, School of Dentistry, Tabriz University of Medical Sciences, Tabriz, Islamic Republic of Iran

**Corresponding Author:** Somaieh Farshidnia, Department of Orthodontics, School of Dentistry, Tabriz University of Medical Sciences, Tabriz, Islamic Republic of Iran, Phone: +989144199893, e-mail: farshidnia@yahoo.com

thermoplastic material (Essix appliance) that has recently become very popular with orthodontic patients due to their proper esthetic appearance, ease of fabrication, and low cost compared with HRs.<sup>1,3</sup> Due to a lack of sufficient evidence-based reasons, selection of removable retainers is carried out to a great extent based on personal preference.<sup>5</sup> On the contrary, one of the factors involved in preferring one type of retainer to another is the long-term stability of the results of orthodontic treatment, occlusal contacts, and proper intercuspation.<sup>6</sup> Several studies have evaluated the efficacy of HR and VFR. Some of these studies have not reported any significant clinical and statistical differences between these two retainers in the intercanine and intermolar widths, the length of the dental arch, and incisor crowding in 12 months.<sup>3</sup> Some others have reported significantly greater changes in incisor crowding in 6 months with the use of HRs compared with VFRs.<sup>7</sup> One of these studies reported differences in the retention capabilities of these two retainers, with the HR allowing more vertical movements in posterior teeth (settling), while the VFR preserved the teeth in their position at the time of debonding.<sup>8</sup> Despite all these studies, a literature search showed that no studies to-date have compared these two retainers in relation to the preservation of gingival health, and only a limited number of studies have compared removable and bonded retainers in relation to their effect on the periodontal status.<sup>9,10</sup>

Based on a suggestion made by Littlewood et al<sup>2</sup> in a systematic review in 2016, more comprehensive and high-quality studies are necessary for the evaluation of the efficacy of different retainers. Therefore, due to the importance of retainers and the necessity of the use of retainers after orthodontic treatment and also due to an increase in the popularity of more esthetic retainers among patients and a lack of consensus among orthodontists for selecting retainers, the present study was undertaken to compare the efficacy of HR and VFR in preserving the results of orthodontic treatment during a 6-month period. To this end, an objective index, i.e., the ABO-OGS, was used. In addition, the gingival health was evaluated during this 6-month period with the use of HR and VFRs with two different thicknesses.

## MATERIALS AND METHODS

The present randomized clinical trial was carried out on 66 patients undergoing comprehensive orthodontic treatment in three private offices in Tabriz after they completed their treatment. A study by Artun et al<sup>11</sup> was used to determine the sample size, in which the mean GI in patients wearing an HR was  $0.77 \pm 0.11$ . The sample size was estimated at 19 subjects in each group (a total of 57 subjects) by considering a difference of 0.1 as clinically

significant at  $\alpha = 0.05$  and a study power of 80%. The sample size in each group was increased to 22 (a total of 66 subjects) by considering a 12% loss of sample size.

The inclusion criteria consisted of completion of orthodontic treatment with an optimal occlusion and an indication for using a removable retainer in the maxilla. Exclusion criteria consisted of loss of several teeth and the need for their prosthetic replacement, patients with bruxism, syndromic conditions (cleft lip and palate, hemifacial microsomia), patients allergic to acrylic resin, patients with temporomandibular joint disorders, oral habits leading to malocclusion, patients undergoing maxillary expansion treatment, early debonding, generalized spacing, any specific systemic condition, periodontal diseases, use of tobacco, and use of any specific medication.

The Randlist software program was used to randomly assign the subjects to three groups. The subjects were matched in relations to factors, such as age, gender, type of malocclusion, severity of crowding, treatment plan (ext or non-ext), and the clinician rendering treatment. All the subjects completed the study and none was excluded from the study.

At the end of orthodontic treatment and after removal of all the orthodontic appliances, alginate (Zhermack Tropicalgin) compressions were taken to prepare study casts of the maxilla and mandible and to fabricate maxillary retainers. The subjects in all the three groups received fixed bonded retainers in the mandible. In group I, HR was used in the maxilla. In group II, VFR was used with a thickness of 1.5 mm, and in group III, VFR was used with a thickness of 1 mm.

Hawley retainer was fabricated with the use of self-cured acrylic resin (Acropars, Tehran, Iran), which consisted of Adams clasps on first molars and a labial bow with 28 mil SS wire (Dentaurum, Germany). The VFRs were fabricated using thermoplastic plates (3A Company, South Korea) with 1 and 1.5 mm thicknesses and trimmed in a manner to be placed at the gingival margin level on the buccal surface and 3 to 4 mm beyond the gingival margin on the lingual surface; the occlusal surfaces of the teeth were covered up to the most distal tooth.<sup>12</sup>

The time interval between impression taking and delivery of the retainers was a maximum of 1 week. The subjects wore the retainers round the clock except at meal times. Irrespective of the retainer type, all the subjects received similar instructions orally and in written form in relation to how to use them, the duration of use, and observation of oral hygiene. The retainers were checked for their fit, presence of any possible injuries, and patient comfort and then delivered to the subjects.

One of the variables evaluated in the present study was the status of gingiva. In all the three study groups, immediately before the delivery of retainers, GI was

determined in the #3, #10, #12, #19, #26, and #28 teeth based on Silness and L oe technique<sup>13,14</sup> and recorded. To this end, four areas in each tooth (buccal and lingual aspects and mesial and distal interdental areas) were evaluated with the use of a 15-UN periodontal probe, and the results were recorded.

Gingival index has been introduced for the evaluation of the status of gingival health; it records qualitative changes in the gingiva. In this technique, the gingival margin and interproximal gingiva are evaluated separately and scored from 0 to 3 based on a set of predefined criteria. This index (GI) can be applied to all the teeth or a number of selected teeth. In addition, GI can be recorded for all the surfaces or a number of selected surfaces.<sup>13,15</sup>

### GI Scores and Criteria

Score 0: Normal gingiva with no inflammation.

Score 1: Mild inflammation; slight changes in color and slight edema, with no bleeding on probing.

Score 2: Moderate inflammation; edema, with bleeding on probing.

Score 3: Severe inflammation; mild edema, ulceration, and tendency for spontaneous bleeding.

Evaluations were repeated 6 months after the initial evaluations and data were recorded. Then, the changes occurring during the 6-month period were determined. The ABO model grading system was used for the evaluation of the stability of treatment outcomes, which was introduced in 1994 by the ABO for the evaluation of the outcomes of orthodontic treatment.<sup>16</sup> In this technique, a special ABO measuring gauge is used to evaluate the seven parameters of occlusion, including alignment, buccolingual inclination, occlusal contacts, overjet, interproximal contacts, marginal ridges, and occlusal relationship. To evaluate the stability of treatment results, once

at the end of orthodontic treatment (before the delivery of the retainer) and once 6 months after the delivery of the retainer, dental casts were prepared and compared.

The ABO-OGS measurements were made by one operator blinded to the type of the retainers used by the patients twice at a 1-week interval. Intraclass correlation (ICC) coefficient and Cronbach's alpha were used to evaluate the agreement and correlation between these two measurements.

All the subjects underwent routine procedures of diagnosis and treatment planning, and none of the subjects was deprived of routine treatment. All the ethical considerations of the present study were supervised and approved by the Ethics Committee of Tabriz University of Medical Sciences under the code IR.TBZMED.REC.1395.1134. The present study was registered at the Iranian Clinical Trials Center website under the code IRCT201722951M3. Before the study, a written informed consent form was signed by each subject after all the procedures were explained to them.

Data were analyzed with descriptive statistical techniques [frequencies, percentages, means, and standard deviations (SDs)] and Kruskal–Wallis and Wilcoxon tests using SPSS, version 20. Kolmogorov–Smirnov and Shapiro–Wilk tests were used for the evaluation of normal distribution of data. Statistical significance was set at  $p < 0.05$ .

### RESULTS

Table 1 presents the results of descriptive analyses and the central and distribution parameters for GI and ABO-OGS indexes at two time intervals. Six months after wearing the retainers, the highest ABO-OGS score was recorded with 1.5 mm VFR ( $14.17 \pm 6.6$ ). In addition, the highest GI score 6 months after the use of retainers was

**Table 1:** Descriptive statistics of the study variables before and 6 months after retainer delivery

	Retainer type	Mean	Confidence interval		Median	SD	Minimum	Maximum
			Lower bound	Upper bound				
Age	Hawley	17.97	16.55	19.39	17	3.87	11	29
	Vacuum-formed, 1.5 mm	19.61	17.35	21.87	17	5.22	14	29
	Vacuum-formed, 1 mm	20.23	17.99	22.47	18	5.55	14	35
ABO before retainer delivery	Hawley	13.42	11.82	15.01	13	4.35	4	24
	Vacuum-formed, 1.5 mm	12.65	10.13	15.18	11	5.84	3	23
	Vacuum-formed, 1 mm	14.04	11.21	16.87	13	7.01	3	25
ABO 6 months after retainer delivery	Hawley	12.81	10.39	15.23	12	6.6	3	33
	Vacuum-formed, 1.5 mm	14.17	11.32	17.03	13	6.6	3	29
	Vacuum-formed, 1 mm	12.92	9.83	16.01	13	7.64	2	31
GI before retainer delivery	Hawley	1.33	1.23	1.43	1.29	0.27	1	2
	Vacuum-formed, 1.5 mm	1.43	1.30	1.57	1.41	0.31	1	2
	Vacuum-formed, 1 mm	1.21	1.12	1.30	1.23	0.22	0.6	1.5
GI 6 months after retainer delivery	Hawley	1.04	0.86	1.21	1.17	0.46	0	2
	Vacuum-formed, 1.5 mm	1.19	1	1.38	1.2	0.44	0	2
	Vacuum-formed, 1 mm	1.13	0.97	1.29	1.18	0.39	0	1.7

**Table 2:** Intraclass correlation and Cronbach's alpha coefficient values

	ICC	Confidence interval		p-value	Cronbach's alpha
		Lower bound	Upper bound		
ABO before retainer delivery					
Single measure	0.83	0.45	0.95	0.001	0.90
Average measures	0.91	0.62	0.98	0.001	
ABO 6 months after retainer delivery					
Single measure	0.61	0.01	0.89	0.023	0.76
Average measures	0.76	0.02	0.94	0.023	

**Table 3:** Evaluation of normal distribution of data with the use of Kolmogorov–Smirnov and Shapiro–Wilk tests

	Retainer type	Kolmogorov–Smirnov		Shapiro–Wilk	
		Statistic	p-value	Statistic	p-value
Age	Hawley	0.147	0.086	0.929	<b>0.041</b>
	Vacuum-formed, 1.5 mm	0.230	<b>0.003</b>	0.842	<b>0.002</b>
	Vacuum-formed, 1 mm	0.203	<b>0.007</b>	0.858	<b>0.002</b>
ABO before retainer delivery	Hawley	0.092	0.200	0.984	0.911
	Vacuum-formed, 1.5 mm	0.133	0.200	0.956	0.384
	Vacuum-formed, 1 mm	0.110	0.200	0.948	0.211
ABO 6 months after retainer delivery	Hawley	0.116	0.200	0.939	0.079
	Vacuum-formed, 1.5 mm	0.179	0.054	0.948	0.269
	Vacuum-formed, 1 mm	0.125	0.200	0.960	0.389
GI before retainer delivery	Hawley	0.165	<b>0.031</b>	0.907	<b>0.011</b>
	Vacuum-formed, 1.5 mm	0.158	0.144	0.893	<b>0.018</b>
	Vacuum-formed, 1 mm	0.173	<b>0.044</b>	0.943	0.157
GI 6 months after retainer delivery	Hawley	0.277	<b>&lt;0.001</b>	0.842	<b>&lt;0.001</b>
	Vacuum-formed, 1.5 mm	0.260	<b>&lt;0.001</b>	0.803	<b>&lt;0.001</b>
	Vacuum-formed, 1 mm	0.210	<b>0.005</b>	0.876	<b>0.005</b>

recorded with 1.5 mm VFR ( $1.19 \pm 0.44$ ). The same clinician repeated ABO-OGS measurements after 1 week. Intraclass correlation and Cronbach's alpha were used to evaluate agreement and correlation between the two measurements. Based on the results presented in Table 2, there was a high level of correlation and agreement between the two measurements.

Kolmogorov–Smirnov and Shapiro–Wilk tests were used to evaluate the normal distribution of data. Based on the results of these tests as presented in Table 3, data related to ABO were distributed normally, but the data related to GI were not distributed normally in cases that are bold-typed.

Kruskal–Wallis test was used to evaluate the differences in means ABO scores with the use of both retainer types between their delivery and 6 months after delivery. In addition, Wilcoxon test was used to compare ABO scores before delivery and 6 months after the delivery of retainers. Based on the results (Table 4), there were no

**Table 4:** Evaluation of differences in the mean ABO scores between the three retainer types with the use of Kruskal–Wallis test

	Statistic	p-value	p-value
ABO before retainer delivery	0.609	2	0.737
ABO 6 months after retainer delivery	0.63	2	0.73

**Table 5:** Evaluation of differences in the mean ABO scores before the delivery of retainers and 6 months after their use with the use of Wilcoxon test

Retainer type	Statistic	p-value
Hawley	-0.68	0.497
Vacuum-formed, 1.5 mm	-1.36	0.175
Vacuum-formed, 1 mm	-1.17	0.242

significant differences in ABO-OGS mean scores before the delivery of retainers between the three retainer groups ( $p = 0.737$ ). In addition, there were no significant differences in these scores between the three retainer types 6 months after the use of retainers ( $p = 0.73$ ).

Based on the results of Wilcoxon test (Table 5), none of the three retainer types exhibited significant differences in ABO-OGS scores between the two time intervals (before the delivery of retainers and 6 months after the use of retainers) ( $p > 0.05$ ).

Due to the normal distribution of data, Kruskal–Wallis test was used to evaluate differences in the mean GI scores in the three retainer types between the two intervals. In addition, since GI scores were not distributed normally, Wilcoxon test was used to compare GI scores between the two time intervals. Based on the results (Table 6), the mean GI scores between the delivery of retainers did not exhibit

**Table 6:** Evaluation of differences in mean GI scores in the three retainer types with the use of Kruskal–Wallis test

	Statistic	Degree of freedom	p-value
GI before retainer delivery	5.7	2	0.058
GI 6 months after retainer delivery	1.3	2	0.523

**Table 7:** Evaluation of differences in GI scores before and 6 months after the delivery of retainers with the use of Wilcoxon test

Retainer type	Statistic	p-value
Hawley	-2.31	0.021
Vacuum-formed, 1.5 mm	-2.39	0.017
Vacuum-formed, 1 mm	-0.55	0.581

any significant differences in any of the three retainer types ( $p = 0.58$ ). In addition, these mean scores did not exhibit any significant differences between the two time intervals in any of the three retainer types ( $p = 0.523$ ).

Based on the results of Wilcoxon test (Table 7), there were significant differences in GI cores of HR and VFR before and 6 months after the delivery of retainers ( $p < 0.05$ ); however, the difference was not clinically significant. Nonetheless, in the 1 mm VFR, the differences were not statistically significant ( $p > 0.081$ ).

## DISCUSSION

The principal challenge in orthodontic treatment is to prevent relapse and to make sure of the stability of the results of treatment. The HR and VFR are the two types of the most commonly used retainers for the maxilla.<sup>17</sup> Despite the use of retainers, unfavorable changes are prevalent in the alignment of teeth after orthodontic treatment. The present study was undertaken to compare the clinical efficacy of HR and VFR with the use of changes in ABO-OGS indexes during a 6-month period after debonding. The first 6-month period after debonding is the time necessary for remodeling of the majority of periodontal and gingival fibers and retention and the full-time use of retainers are very important. In addition, the patients exhibit a high level of cooperation during this period.<sup>5,18</sup> Therefore, we selected this time period.

The results of the present study showed that during the 6-month period after orthodontic treatment, there were no significant differences in ABO-OGS index scores between HR and VFR.

Consistent with the results of the present study, Barlin et al evaluated 42 patients receiving HRs and 40 patients receiving VFRs in relation to the intercanine and intermolar widths, the arch length, and incisor crowding index 2, 6, and 12 months after completion of fixed orthodontic treatment and concluded that there were no significant clinical differences between the two retainers in the variables evaluated during the 12-month period.<sup>3</sup> Another study which is consistent with the present study, despite its different design, is a study carried out by Demir et al,<sup>7</sup> in which 22 patients receiving VFRs and 20 patients receiving HRs were evaluated during a 1-year retention period and during a 2-year follow-up period. The variables that were evaluated consisted of intercanine width,

arch length, and incisor crowding index. Demir et al concluded that these two retainers had similar retention properties. In preserving the position of mandibular incisors, VFR was more successful than HR; however, in the maxilla, they did not exhibit any statistically significant differences. Rowland et al<sup>18</sup> carried out a study on 201 patients receiving VFR and 196 patients receiving HR in a 6-month period after the completion of orthodontic treatment and concluded that the efficacy of HR and VFR was similar in preserving rotation, intercanine width, and intermolar width, despite the old belief that VFR is not successful in preserving the stability of the arch width due to its lack of rigidity. In addition, Rowland et al<sup>18</sup> concluded that VFR was a little more successful than HR in preserving the alignment of the labial segment. It should be pointed out that the difference in the maxilla was not clinically and statistically significant (the changes in irregularity index were 0.51 and 0.26 with HR and VFR respectively), somehow confirming the results of the present study.

In the majority of studies, parameters, such as intercanine and intermolar widths and arch length have been evaluated for the clinical efficacy of HR and VFR. However, these parameters are only some aspects of relapse, which might not be tangible for the patients, and do not provide us with a comprehensive concept of occlusal status and the overall amount of relapse. The present study compared these two retainers with the use of ABO-OGS index, which has been introduced for the evaluation of the quality of orthodontic treatment. Therefore, its changes might provide a comprehensive evaluation of the stability of the outcomes of orthodontic treatment.

On the contrary, this index consists of seven criteria and measurements on dental casts. Therefore, changes in this index indicate an estimate of the overall changes in these criteria and do not show the exact location of these differences. It might be advisable to evaluate changes in each of the ABO-OGS parameters separately in different retainers (e.g., a change in alignment). Another limitation of ABO-OGS index is a lack of evaluation of overbite. It has been reported that VFR does not cover the plate completely and is not as effective as HR to prevent deepening of the bite.<sup>17</sup> A study in 2005 by Qanber Agha et al<sup>19</sup> showed that during a 3-month retention period, the

amount of decrease in overbite in HR was significantly higher than that of VFR, which is due to the eruption of posterior teeth during the use of HR. In the present study, overbite was not evaluated.

Based on the searches carried out and a systematic review in 2014 by Mai et al,<sup>17</sup> no study to-date has evaluated the periodontal status during the retention period with the use of HR and VFRs. However, due to the long-term use of retainers, evaluation of the possible effect of these appliances on the health of gingival tissue is very important. This study showed for the first time no differences in the use of VFR and HR in relation to the gingival health.

One of the limitations of removable retainers is their dependence on patient cooperation, and the orthodontist has no control on their use. In this context, if the retainer is not used according to the instructions, relapse will be inevitable. Therefore, the introduction of a retainer which is more probably accepted by the patient will benefit both the clinician and the patient. Studies have shown that patients exhibit better compliance with VFRs compared with HRs,<sup>20,21</sup> which might be attributed to the fact that VFRs are made of transparent plastic materials, and exhibit a higher level of esthetic appearance, in contrast to HRs that are made of acrylic resin in association with a labial bow on anterior teeth and clasps on molar teeth. In addition, several studies have reported that VFRs are manufactured at lower costs compared with HRs.<sup>17,22</sup> In addition, Wan et al<sup>23</sup> showed changes in articulation (speech) in both groups receiving HR and VFR, with more changes with the use of HRs. In another study, patients receiving VFR felt less shy and exhibited more self-confidence.<sup>23</sup> Therefore, based on what was discussed above and also the results of the present study, it appears logical to suggest the use of VFRs in contrast to HRs.

However, considering the limitations of the present study, more precise and comprehensive studies with larger sample sizes are necessary to confirm the results of the present study. In addition, relapse is a long-term problem that requires long-term follow-up of patients in contrast to 3-, 6-, or 12-month follow-ups. Therefore, despite the difficult and costly nature of long-term follow-ups, they will be useful in achieving more real results.

## CONCLUSION

The results of the present study showed no significant clinical and statistical differences in the stability of the results of orthodontic treatment between HR and VFR during the 6-month period after orthodontic treatment based on ABO-OGS index, and there was no significant difference in gingival tissue health based on the GI.

## Clinical Relevance

Due to its better esthetic appearance and patient acceptance, VFR might be an alternative for HR.

## REFERENCES

1. Raja TA, Littlewood SJ, Munyombwe T, Bubb NL. Wear resistance of four types of vacuum-formed retainer materials: a laboratory study. *Angle Orthod* 2014 Jul;84(4):656-664.
2. Littlewood S, Millett D, Doubleday B, Bearn D, Worthington H, Sampson WJ. Retention procedures for stabilizing tooth position after treatment with orthodontic braces. *Aust Dent J* 2016 Jan;51:94-95.
3. Barlin S, Smith R, Reed R, Sandy J, Ireland AJ. A retrospective randomized double-blind comparison study of the effectiveness of Hawley vs vacuum-formed retainers. *Angle Orthod* 2011 May;81(3):404-409.
4. Proffit WR, Fields Jr HW, Sarver DM. *Contemporary Orthodontics*. 5th ed. Elsevier Health Sciences; 2014. pp. 150-210.
5. Bibona K, Shroff B, Best AM, Lindauer SJ. Factors affecting orthodontists' management of the retention phase. *Angle Orthod* 2014 Mar;84(2):225-230.
6. Bauer EM, Behrents R, Oliver DR, Buschang PH. Posterior occlusion changes with a Hawley vs perfector and Hawley retainer. A follow-up study. *Angle Orthod* 2010 Sep;80(5):853-860.
7. Demir A, Babacan H, Nalcaci R, Topcuoglu T. Comparison of retention characteristics of essix and Hawley retainers. *Korean J Orthod* 2012 Oct;42(5):255-262.
8. Sauguet E, Covell DA Jr, Boero RP, Lieber WS. Comparison of occlusal contacts with use of Hawley and clear overlay retainers. *Angle Orthod* 1997;67(3):223-230.
9. Heier EE, De Smit AA, Wijgaerts IA, Adriaens PA. Periodontal implications of bonded versus removable retainers. *Am J Orthod Dentofacial Orthop* 1997 Dec;112(6):607-616.
10. Torkan S, Oshagh M, Khojastepour L, Shahidi S, Heidari S. Clinical and radiographic comparison of the effects of two types of fixed retainers on periodontium—a randomized clinical trial. *Prog Orthod* 2014 Aug;15:47.
11. Artun J, Spadafora AT, Shapiro PA. A 3-year follow-up study of various types of orthodontic canine-to-canine retainers. *Eur J Orthod* 1997 Oct;19(5):501-509.
12. Sun J, Yu Y, Liu M, Chen L, Li H, Zhang L, Zhou Y, Ao D, Tao R, Lai WL. Survival time comparison between Hawley and clear overlay retainers: A randomized trial. *J Dent Res* 2011 Oct;90(10):1197-1201.
13. Löe H. The gingival index, the plaque index and the retention index systems. *J Periodontol* 1967 Nov-Dec;38(6):610-616.
14. Rebelo MA, De Queiroz AC. Gingival indices: State of art. *IN TECH*; 2011.
15. Wei SH, Lang KP. Periodontal epidemiological indices for children and adolescents: I. Gingival and periodontal health assessments. *Pediatr Dent* 1981 Dec;3(4):353-360.
16. Casco JS, Vaden JL, Kokich VG, Damone J, James RD, Cangialosi TJ, Riolo ML, Owens SE Jr, Bills ED. Objective grading system for dental casts and panoramic radiographs. American Board of Orthodontics. *Am J Orthod Dentofacial Orthop* 1998 Nov;114(5):589-599.
17. Mai W, He J, Meng H, Jiang Y, Huang C, Li M, Yuan K, Kang N. Comparison of vacuum-formed and Hawley retainers: a systematic review. *Am J Orthod Dentofacial Orthop* 2014 Jun;145(6):720-727.

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18. Rowland H, Hichens L, Williams A, Hills D, Killingback N, Ewings P, Clark S, Ireland AJ, Sandy JR. The effectiveness of Hawley and vacuum-formed retainers: a single-center randomized controlled trial. *Am J Orthod Dentofacial Orthop* 2007 Dec;132(6):730-737.
19. Qanber Agha RA, Ghaib NH. Relapse during retention with Hawley and clear overlay retainers in Iraqi adults. *Iraqi Orthod J* 2005;1(2):10-12.
20. Pratt MC, Kluemper GT, Lindstrom AF. Patient compliance with orthodontic retainers in the postretention phase. *Am J Orthod Dentofacial Orthop* 2011 Aug;140(2):196-201.
21. Mirzakouchaki B, Shirazi S, Sharghi R, Shirazi S. Assessment of factors affecting adolescent patients' compliance with Hawley and vacuum formed retainers. *J Clin Diagn Res* 2016 Jun;10(6):ZC24-ZC27.
22. Hichens L, Rowland H, Williams A, Hollinghurst S, Ewings P, Clark S, Ireland A, Sandy J. Cost-effectiveness and patient satisfaction: Hawley and vacuum-formed retainers. *Eur J Orthod* 2007 Aug;29(4):372-378.
23. Wan J, Wang T, Pei X, Wan Q, Feng W, Chen J. Speech effects of hawley and vacuum-formed retainers by acoustic analysis: a single-center randomized controlled trial. *Angle Orthod* 2017 Mar;87(2):286-292.