

Clinical performance comparison of a clear advantage series II durable retainer with different retainers' types

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ABSTRACT

Background: The orthodontic retainers are either fixed or removable. Each has its own advantages and disadvantages. The goal of the current study was to evaluate the new Clear Advantage Series II durable thermo-vacuum formed invisible orthodontic retainer material and compare the clinical performance of such retainer with the most standard types of retainers (convention Clear Advantage Series I thermo-vacuum formed invisible retainer, Hawley, and the fixed lingual bonded retainers). The conducted study is the first attempt to evaluate and compare the clinical performance of different retainers' types.

Subjects and methods: Twenty finished fixed orthodontic patients starting the retention phase were divided into four groups. Each group consisted of five patients (3 females and 2 males), mean age ranged 18-30 years old. Members of the first group were given the new thermo-vacuum formed invisible Clear Advantage Series II durable retainer material (CII), While the second, third, and fourth groups were given standard thermo-vacuum formed invisible Clear Advantage Series I retainer material (CI), Hawley retainer (HR), and fixed lingual bonded retainers "cuspid to cuspid"(FR), respectively. Ten variables were applied on the twenty patients to evaluate the clinical performance of the four retainers' types, the ten variables were evaluated and judged by the operator with the patient as three non-parametric categorical descriptions: superior (+), acceptable (\pm), and inferior (-) properties.

Results: It was found that patients were compliant with all types of retainers initially, and the compliance decreased at a much faster rate with both types of thermo-vacuum formed retainers (CII and CI) than with HR and FR retainers, and patient's compliance is greater with HR and FR retainers than with CII and CI retainers. A comparison of the total variables of the clinical performance at total time intervals using chi-square showed that there was a significant difference ($P < 0.05$) in the acceptable categorical description between CII and CI retainers and very high significant difference ($P < 0.001$) between CII, HR, and FR retainers.

Conclusion: it was found that the new thermo-vacuum formed Clear Advantage Series II durable retainer showed a combination of removable, comfortable, aesthetic, better speech, superior retention, relatively not producing bad taste and odor, hygienic, least soft tissue irritability, superior construction and chair-side time, and durable, it will be more favorable clinical performance appliance to both the patient and the orthodontist.

Keywords: Clinical performance, Clear Advantage Series II Durable, Retainers. (J Bagh Coll Dentistry 2012;24(2):127-136).

INTRODUCTION

In orthodontics, although the patient may feel that treatment is complete when the appliances are removed, an important stage lies ahead, which is the retention phase, retention has been defined by Moyers ⁽¹⁾ as the process of maintaining the moved teeth into the new position long enough to aid in stabilizing their correction. Relapse has been defined as a return of teeth to their original position or a shift in arch relationship after the end of treatment, because teeth tend to move back to their pre-treatment positions if they are not retained ⁽²⁻⁴⁾. The etiology of relapse is multifactorial and can be divided into three main areas: physiological recovery, unfavorable growth, or "true relapse" due to the placement of the teeth in an unstable position ⁽⁴⁾.

Reitan ⁽⁵⁾ in 1967 showed that periodontal ligament takes 232 days to reorganize and can derotate teeth after one years. The periodontal ligament requires three to four months' masticatory stimulation for organization of its fibers.

In addition, research has shown that alveolar bone is laid down after one month and supracrestal fibers require one year to remodel, therefore, retention and relapse are considered as vital issues of a complete and a successful orthodontic treatment ⁽²⁾. There are literatures on retention and post-treatment relapse, which have been reviewed in some depth ⁽⁵⁻⁸⁾.

In orthodontic, there are grossly two types of orthodontic retainers: removable (commonly temporary), and fixed (commonly permanent) ⁽⁹⁻¹¹⁾. A temporary retainer is designed for a relatively limited retention period to allow for the reorganization of the gingival & periodontal tissues ⁽⁸⁾. Henry Baker used maxillary and mandibular vulcanite removable retainers with labial wires, but the vulcanite was not adapted to the teeth. Instead, the teeth were prevented from moving lingually by metallic spurs embedded in the vulcanite ⁽¹²⁾. The retainers of Chartes A. Hawley ⁽¹³⁾ in 1919 were an improvement over Baker's in that the base material was flowed against the lingual surfaces, thus helping to prevent rotations. In 1930s, vulcanite was replaced by acrylic, and till now the orthodontists are using the Hawley retainer and its many known modification ⁽¹²⁻¹⁴⁾. The invisible retainers was

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developed by Robert Pointz ⁽¹⁵⁾ in 1971, later on Essix retainers were introduced by Sheridan et al ⁽¹⁶⁾ in 1993. Typically such invisible retainers are formed from a sheet of thin Biocryl™, or other similar material that is heated & formed by suction or pressure on to a work model of the dentition ⁽¹⁵⁻¹⁸⁾.

The purpose of the current study was to evaluate the new Clear Advantage Series II durable retainer and compare the clinical performance of such retainer with the most standard types of retainers (convention Clear Advantage Series I thermo-vacuum formed invisible retainer, Hawley, and the fixed lingual bonded retainers).

SUBJECTS AND METHODS

Twenty finished fixed orthodontic patients attended a private clinic in Baghdad city, starting the retention phase were selected from 29 patients after discussion the study with them from ethical approval point of view, and only those willing to provide complete co-operation were enrolled in the study and fully informed consents were taken, the twenty patients were divided into four groups. Each group consisted of five patients (3 females and 2 males), mean age ranged 18-30 years old.

Patient exclusion criteria:

1. Craniofacial anomalies, symptoms of temporomandibular joint disorders, history of orthognathic surgery, or bad habits.
2. Unsatisfied patients to the final orthodontic fixed treatment objectives.
3. Unavailable patients for long term (1 year) follow-up evaluation.

Methodology: The treatment protocol was as follow:

All participants were previously treated with Roth system upper and lower fixed orthodontic appliances (Bracket's slot size 0.022", Pyramid Orthodontics, CA; USA). An alginate impressions (Tropicalgin-normal setting Zhermack®; Italy) were taken by assorted sizes rim lock trays (Frontier Dental Industrial Co., China) for the patients' upper and lower dental arches then poured with type four thixotropic die stone (Elite Stone - Zhermack; Italy) after considering the manufacturer instructions. All retainers were fabricated by the same private laboratory. Members of the first group were given the new thermo-vacuum formed invisible Clear Advantage Series II durable retainer material, thermal forming coping polypropylene; 0.040 of an inch (OrthoTechnology-Tampa, Florida; USA). While the second, third, and fourth groups were given standard thermo-vacuum formed invisible Clear Advantage Series I thermal forming splint/copolyester retainer material; 0.040 of an

inch (OrthoTechnology-Tampa, Florida, USA), Hawley retainer fabricated with polymethylmethacrylate "powder and liquid" (Orthocryl®, Dentaurum, Ispringen, Germany) and 0.7mm hard stain-less steel wire (Dentaurum, Ispringen, Germany), and fixed lingual bonded retainers "cuspid to cuspid" with assorted sizes (Ortho Matrix; USA) bonded with light activated orthodontic bonding system (Resilience®, Ortho Technology-Tampa, Florida; USA), respectively, the retainers' materials were shown in figure 1. The Clear Advantage Series II thermo-vacuum formed durable invisible retainer, the Clear Advantage Series I thermo-vacuum formed standard invisible retainer, and the fixed bonded lingual retainer were placed on the same day as the fixed appliances were removed, while the Hawley retainers were placed one to seven days after the removal of the fixed appliances, the four types of retainers were shown in figures 2 to 5.

Ten variables were applied on the twenty patients to evaluate the clinical performance of the four retainers' types, the ten variables were evaluated and judged by the operator with the patient as three non-parametric categorical descriptions: superior (+), acceptable (±), and inferior (-) properties, these ten variables were.

1. Versatility: it indicates the adaptability and comfort of the patient to the retainer.
2. Aesthetic: It means the beauty and the invisibility of the retainer.
3. Speech: It indicates the effect of the retainer on speech.
4. Retention: It indicates the stability of the retainer during rest and animation.
5. Bad taste and odor: It refers if the retainer produces a bad taste and smell.
6. Caries risk: It refers to the hygienic property of the retainer.
7. Soft tissue irritability: It refers to the ability of the retainer to produce irritation to the soft tissue (gingival, lip, cheek, and tongue).
8. Construction times: It refers to how much time does it need to construct the appliance till insertion inside the patient's mouth, noted as superior (short time), acceptable (intermediate time), and inferior (long time).
9. Chair-side time: It refers to how much time does it need to place, fit, or bond the retainer at each visit, also it involves the time needed for repairing the appliance.
10. Failure of retention material: It refers to the durability of the retainer's material inside the patient's mouth. Without crack, perforation, fracture, or debonding.

The clinical performance of the new Clear Advantage Series II durable thermo-vacuum formed invisible retainer was evaluated at the time of retainer insertion, three months, six months, and one year post-insertion follow-up^(19,20) in comparison with the three of the most standard and commonly used retainers; convention Clear Advantage Series I thermo-vacuum formed invisible retainer, Hawley, and the fixed lingual bonded retainers.

All patients received upper and lower retainers, the invisible retainers were full coverage type, and the patient should wear the removable retainer full day time (except during meals for thermo-vacuum formed retainers) for six months, and then at night only for the next six months⁽²¹⁾.

Statistical analysis: The data were collected and subjected to computerized statistical analysis using statistical Package for Social Science computer software (SPSS, version 17), in which the description for the non-parametric categorical variables represented by observed number and percentage of occurrence, while the inferential statistics included the use of Chi-square for comparison of the categorical data among the four types of retainers. Probability levels of less than 5%, 1%, and 0.1% were regarded as statistically significant, highly significant, and very highly significant, respectively.

Method error: It was calculated to determine the reproducibility and reliability of the categorical descriptions of clinical performance, the categorical descriptions of five patients were evaluated two times, first by the researcher, and second time by another observer. Kappa test (GraphPad Software, Inc.; USA) was used to evaluate the inter-observer agreement, it was found equal to 0.8 which indicates a very good strength of agreement.^(4,22)

RESULTS AND DISCUSSION

There are insufficient data on which to base our clinical practices on retention present, several retainer designs have examined over time, with various retention protocols to minimize relapse^(19,23-25). Because of the lack of scientific evidence on retention protocols, it appears that previous recommendations are based largely on personal preference and non-scientific criteria^(4,25). The clinical performance of different retainers' types is a vital area of orthodontic research, and it should be given priority on our concern. As far as being aware, no research has been published that addresses the evaluation of the clinical performance of different retainers' types.

Many studies conducted onto survey the orthodontic trends over the past 25 years in

Australia, New Zealand, United States and United Kingdom to identify consistencies in retention procedures and found that the most commonly used retainers were invisible retainers (vacuum-formed) and canine to canine bonded lingual retainers. Hawley retainers declined in use from 1986 to 2011, whereas invisible retainers and fixed bonded canine to canine retainers increased⁽²⁵⁻²⁸⁾. Therefore, in the current study, the new retainer (Clear Advantage Series II durable retainer) was compared with the most commonly used retainers in orthodontics (standard thermo-vacuum formed invisible retainer, Hawley, and fixed bonded lingual retainers). On the other hand, it is very important to explain fully the importance of retainers and of proper handling and regular checkups to patients⁽⁴⁾. Patients need to be recalled after different time intervals in order to instruct, checkup, adjust, and remove any discomfort, therefore, in the current study, different time intervals (At time of retainer insertion, three months, six months, and one year post-retainer insertion) were selected to evaluate the clinical performance of these retainers^(19,20).

Tables one to four described the variables' characteristics of clinical performance. Regarding the versatility (comfort and adaptability), the Clear Advantage Series II durable invisible retainer (CII) showed that there was an inferior categorical description property expressed by a low observed numbers and percentages of occurrence at the time of retainers insertion, the superior and acceptable categorical descriptions increase after three months, then became the same description after six months and one year post-retainer insertion, while the Clear Advantage Series I standard thermo-vacuum formed invisible retainer (CI) showed an increase in the superior and acceptable categorical descriptions from the time of insertion to three months post-insertion, this may be due to adaptation of stomatognathic system to the new appliance inserted inside the patient's mouth, the inferior description increases from six months to one year post-insertion, this may be due to cracks produced at the margins of the retainer that can reduce the adaptation and comfort of the patient to this type of retainer. The Hawley retainer (HR) showed an increase in the superior and acceptable categorical descriptions from time of insertion to the three months post-insertion due to the adaptation process, while the inferior description increases from six months to one year post-insertion, this may be due that such type of retainer contains thick and bulk acrylic base plate and orthodontic wires that are liable to deformation and need periodic adjustment, so the versatility decreased

with time, so that it will negatively affect the adaptation and comfort. The fixed bonded lingual retainer (FR) showed an increase in the superior categorical description with time, this may also be due to adaptation of the tongue to the fixed bonded lingual retainer.

Regarding the esthetic point of view the CII, CI, and FR showed high observed numbers and percentages of occurrence for superior and acceptable descriptions, this is due to the translucent property of clear invisible (CII and CI) retainers, even though the CII retainer is slight cloudy than the CI retainer, but when the CII retainer is subjected to heat during thermal vacuum forming process, such cloudiness is decreased and became unnoticeable when the CII is inserted inside the patient's mouth, so both types of clear invisible (CII and CI) retainers exhibited superior and acceptable properties, the fixed bonded lingual retainer (FR) was positioned lingually, therefore it exhibits better esthetic, while the HR showed an increase of the superior and acceptable categorical descriptions with time, this may be due to better psychological adaptation to the shape of this retainer.

Regarding the speech, all types of retainers showed increase in the superior and acceptable categorical descriptions with time due to the adaptation of the patient's tongue and lips to the retainers with time factor, so phonetic improvement will occur.

Regarding the retention, the CII and CI retainers showed superior categorical description, and not affected by time, because these retainers' types depend on negative pressure, accurate fitness, and interfacial forces to achieve their retention^(3,4,23), while the HR showed increase in the inferior categorical description with time because such type of retainers had wires that need periodic adjustment, the FR showed also increase in the inferior property with time, this may be due to the increase of the bonding failure of FR with time, which can subsequently affect the overall retention of this type of retainer.

Regarding the bad taste, the CII and CI retainers showed superior categorical description and not affected by the factor of time, while HR showed inferior description at time of insertion, this may be due to the residual monomer of methyl methacrylate, the inferior property decreases after three months and six months post-insertion, then the inferior property will increase after one year post-insertion, this may be due to microbial plaque accumulation at the acrylic base plate that can affect the taste and odor, this explanation agreed with other research⁽⁸⁾, the FR showed high inferior property at time of insertion,

due to the bad taste of the etchant and primer, which can negatively affect the taste, then with time there will be an increase in the inferior property of bad taste and odor, due to unhygienic plaque accumulation property of this type of retainer^(9,10).

Regarding the caries risk, all types of removable retainers showed high observed numbers and percentages of occurrence of superior categorical description property and remained high with time, except the FR showed high inferior property with time because of difficulty in maintaining good oral hygiene with such type of retainer, while all removable retainers can be removed outside the patient's mouth, so it is better to perform a good oral hygiene maintenance with such type of retainers^(9,10).

Regarding soft tissue irritability, CII and CI retainers showed high observed numbers and percentages of occurrence of the superior categorical description property and remained the same with time because both retainers' thickness were one millimeter and contained no wires, so less soft tissue irritability, while HR showed high inferior property and remained the same observed numbers and percentages after three months, six months, and one year post-insertion, because this type of retainers contained wires and relatively thick bulky acrylic base plate that can affect on the surrounding soft tissue. However, it is well known that the major advantage of HR is the ability of the patient to perform optimal oral hygiene care, the major disadvantage of such retainer is the acrylic base plate, which is basically thick and bulky, such bulk affects speech negatively, potentially toxic irritable and unhygienic upon prolong wearing⁽⁸⁾, some authors said that HR allows vertical settling of the teeth⁽²⁹⁻³¹⁾. But settling of teeth should be carried out during the last phase of active treatment rather than in the retention period⁽³⁰⁻³²⁾, the FR showed high observed number and percentage of the inferior categorical property and both increase with time, this may be due to the ability of this type of retainer to cause irritation to the surrounding soft tissue due to plaque retentive ability, on the other hand, the major advantage of the fixed retainer was the close relation between the bonded teeth, resulting in their consolidation to act clinically as a stable dental unit, such consolidation maintains the position of the dentition even in the presence of unfavorable or unbalanced soft tissue forces^(9,33).

Regarding the construction time, CII and CI invisible retainers showed high superior categorical property, because such retainers need

about one hour from impressions till their insertion inside the patient's mouth, while HR showed high inferior categorical property because it needs one to seven days till retainer insertion because it needs a laboratory work, so it can be concluded that the thermoplastic invisible retainers (CII and CI) showed a reduction in the laboratory fabrication, and the fabrication technique is simple and no technical proficiency in wire bending or knowledge of the properties of dental laboratory acrylic is required, this is in accordance with other studies^(16,18).

Regarding chair-side time, the CII retainer showed the highest superior categorical property, followed by CI, HR, and FR respectively, the superior property remains high with time, because CII retainer showed the most durable retainer, and it does not need any repairing, subsequently less chair-side time, while the other retainers' types were more liable to repair, therefore, more chair-side time, the FR showed an increase in the inferior property with time, because it exhibited more debonding failures and subsequently more chair-side time. It might be better to assess and compare the number of failures and rebonding appointments, it might be that the increased mobility of the teeth because of periodontal problem in the post-treatment period favors detachments, failures can be inherent, as a result of poor chair-side technique, or acquired, from wear or direct trauma to the retainer^(34,35).

Regarding failure of retention material, the CII retainer showed superior categorical property because this type of retainer is most durable retainer than other retainers' types, and it does not be affected by the time factor, while the FR, CI, and HR showed inferior categorical property changing from high to low respectively, this may be due to the multiple debonding failures of FR, cracks and their propagation and subsequent fracture of the margins of CI, and fracture of the orthodontic wires and/or fracture of acrylic base plate resulting in failure of the retainer, respectively, as shown in tables one to four, so it can be concluded that the CII retainer overcomes the cracks and fracture problem often encountered with the use of CI and HR retainers and debonding failures associated with FR. There is little doubt that corrosive wear is an important factor in the durability of thermoplastic retainers, chemicals and certain bicarbonated drinks can plasticize certain polymers (polypropylene of CII, and copolyesters of CI retainers), temperature change of water inside patient's mouth can cause filler leaching, and certain micro-organisms produce esterase enzymes that can degrade polymers^(36,37).

A comparison of the total variables of the clinical performance at total time intervals using chi-square showed that there was a significant difference ($P < 0.05$) in the acceptable categorical description between CII and CI, as demonstrated in table 6, this may be due to the significant difference of the acceptable categorical description between CII and CI retainers after 3 months post-retainer insertion as shown in table 5, which it plays an important role in the final difference between the two types of retainers as shown in table 6, while a clinical performance comparison between CII, HR, and FR showed very high significant difference ($P < 0.001$) between all categorical descriptions of these variables for total time intervals, this may be due to the very high significant difference of the acceptable categorical description property between CII, HR, and FR retainers after 3 months, 6 months, and 1 year post-insertion as shown in table 5, so it can be concluded that the new CII retainer seems to have several advantages when compared to the three standard orthodontic retainers (CI, HR, and FR). Taking into consideration, the main positive and negative aspects of the four types of retainers used in the current study, it was thought that a combination of removable, comfortable, aesthetic, better speech, superior retention, relatively not producing bad taste and odor, hygienic, least soft tissue irritability, superior construction and chair-side time, and durable, will be more favorable appliance to both the patient and the orthodontist. However, the major disadvantage of the new CII retainer was that it does not bond to acrylic because polypropylene material of this type of retainer is considered as a non-stick plastic, basically it has inert or inactive molecular structure, therefore described as a low energy state⁽²⁹⁾. There was a very high significant difference ($P < 0.001$) in the superior and inferior categorical properties and non-significant difference ($P > 0.05$) in the acceptable categorical description property between CI, HR, and FR for total time of the total variables of clinical performance, as shown in table 6, this may be due to the non-significant difference in the acceptable categorical description between CI, FR, and HR after 6 months, and one year post-insertion, respectively, for total variables of clinical performance as described in table 5. So it can be concluded that the overall clinical performance comparison between CI retainer and HR is as the same as that between CI and FR, as demonstrated in table 6. There was a non-significant difference ($P > 0.05$) between HR and FR for all categorical descriptions at total time intervals, so it can be

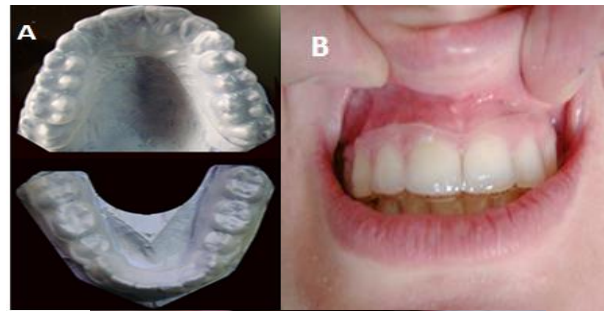
concluded that HR and FR also exhibited the same overall clinical performance. In addition, it was found that patients were compliant with all types of retainers, and the compliance decreased at a much faster rate with both types of thermo-vacuum formed retainers (CII and CI) than with HR and FR. As a conclusion, patient's compliance is greater with HR and FR retainers than with CII and CI retainers, this agreed with other researches (25,38)

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Figure 1: Retainers' materials, A: Clear Advantage Series II durable retainer material, B: Clear Advantage Series I retainer material, C and D: Polymethyl-methacrylate "powder and liquid" and 0.7mm hard stain-less steel wire for fabrication of Hawley retainer, E and F: Fixed lingual bonded retainers "cuspid to cuspid" with assorted sizes bonded with light activated orthodontic bonding system.



Figures 2 A - E: The Clear Advantage Series II thermo-vacuum formed durable invisible retainer.



Figure 3: Clear Advantage Series I thermo-vacuum formed invisible



Figure 4: Hawley retainer inside a patient's mouth. retainer.



Figure 5: Fixed lingual bonded retainers "cuspid to cuspid"

Table 1: Descriptive statistics for the clinical performance evaluation of the four types of retainers at the time of insertion using observed numbers and percentage of occurrence.

	Clear Advantage Series II Durable invisible retainer N=5			Clear Advantage Series I standard invisible retainer N=5			Hawley retainer N=5			Fixed bonded lingual retainer N=5		
	+	±	-	+	±	-	+	±	-	+	±	-
Versatility	1 (20%)	3 (60%)	1 (20%)	1 (20%)	3 (60%)	1 (20%)	0 (0%)	1 (20%)	4 (80%)	0 (0%)	1 (20%)	4 (80%)
Aesthetic	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	0 (0%)	1 (20%)	4 (80%)	5 (100%)	0 (0%)	0 (100%)
Speech	1 (20%)	3 (60%)	1 (20%)	1 (20%)	3 (60%)	1 (20%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	1 (20%)	4 (80%)
Retention	4 (80%)	1 (20%)	0 (0%)	4 (80%)	1 (20%)	0 (0%)	4 (80%)	1 (20%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)
Bad taste and odor	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	1 (20%)	2 (40%)	2 (40%)	1 (20%)	1 (20%)	3 (60%)
Caries risk (Hygienic)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Soft tissue irritability	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	1 (20%)	1 (20%)	3 (60%)	1 (20%)	2 (40%)	2 (40%)
Construction Time	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	0 (0%)	1 (20%)	4 (80%)	1 (20%)	3 (60%)	1 (20%)
Chair- side time	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	0 (0%)	1 (20%)	4 (80%)
Failure of retention material	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Total variables	31 (77.5%)	7 (7.55%)	2 (5%)	31 (77.5%)	7 (7.55%)	2 (5%)	11 (27.5%)	7 (7.5%)	22 (55%)	13 (32.5%)	9 (22.5%)	18 (45%)

+ : Superior . ± : Acceptable. - : Inferior. N: Number of subjects.

Table 2: Descriptive statistics for the clinical performance evaluation of the four types of retainers after three months post- insertion using observed numbers and percentage of occurrence.

	Clear Advantage Series II Durable invisible retainer N=5			Clear Advantage Series I standard invisible retainer N=5			Hawley retainer N=5			Fixed bonded lingual retainer N=5		
	+	±	-	+	±	-	+	±	-	+	±	-
Versatility	4 (80%)	1 (20%)	0 (0%)	4 (80%)	1 (20%)	0 (0%)	1 (20%)	3 (60%)	1 (20%)	1 (20%)	1 (20%)	3 (60%)
Aesthetic	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	1 (20%)	1 (20%)	3 (60%)	5 (100%)	0 (0%)	0 (0%)
Speech	3 (60%)	1 (20%)	1 (20%)	3 (60%)	1 (20%)	1 (20%)	2 (40%)	2 (40%)	1 (20%)	0 (0%)	2 (40%)	3 (60%)
Retention	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	3 (60%)	2 (40%)	0 (0%)	3 (60%)	1 (20%)	1 (20%)
Bad taste and odor	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	1 (20%)	3 (60%)	1 (20%)	1 (20%)	2 (40%)	2 (40%)
Caries risk (Hygienic)	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	0 (0%)	2 (40%)	3 (60%)
Soft tissue irritability	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	1 (20%)	2 (40%)	2 (40%)	1 (20%)	3 (60%)	2 (40%)
Construction Time	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Chair- side time	5 (100%)	0 (0%)	0 (0%)	1 (20%)	4 (80%)	0 (0%)	1 (20%)	4 (80%)	0 (0%)	1 (20%)	1 (20%)	3 (60%)
Failure of retention material	5 (100%)	0 (0%)	0 (0%)	1 (20%)	3 (60%)	1 (20%)	2 (40%)	2 (40%)	1 (20%)	2 (40%)	2 (40%)	1 (20%)
Total variables	42 (93.3%)	2 (4.4%)	1 (2.22%)	34 (75.5%)	9 (20%)	2 (4.44%)	17 (37.7%)	19 (42.2%)	9 (20%)	14 (31.1%)	13 (28.8%)	18 (40%)

+ : Superior . ± : Acceptable. - : Inferior. N: Number of subjects

Table 3: Descriptive statistics for the clinical performance evaluation of the four types of retainers after six months post- insertion. using observed numbers and percentage of occurrence

	Clear Advantage Series II Durable invisible retainer N=5			Clear Advantage Series I standard invisible retainer N=5			Hawley retainer N=5			Fixed bonded lingual retainer N=5		
	+	±	-	+	±	-	+	±	-	+	±	-
Versatility	5 (100%)	0 (0%)	0 (0%)	2 (40%)	2 (40%)	1 (20%)	1 (20%)	3 (60%)	1 (20%)	1 (20%)	2 (40%)	2 (40%)
Aesthetic	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	2 (40%)	2 (40%)	1 (20%)	5 (100%)	0 (0%)	0 (0%)
Speech	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	4 (80%)	1 (20%)	0 (0%)	0 (0%)	3 (60%)	2 (40%)
Retention	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	3 (60%)	2 (40%)	0 (0%)	3 (60%)	1 (20%)	1 (20%)
Bad taste and odor	4 (80%)	1 (20%)	0 (0%)	4 (80%)	1 (20%)	0 (0%)	1 (20%)	3 (60%)	1 (20%)	1 (20%)	2 (40%)	2 (40%)
Caries risk (Hygienic)	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	0 (0%)	2 (40%)	3 (60%)
Soft tissue irritability	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	1 (20%)	2 (40%)	2 (40%)	1 (20%)	1 (20%)	2 (40%)
Construction Time	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Chair- side time	5 (100%)	0 (0%)	0 (0%)	3 (60%)	1 (20%)	1 (20%)	1 (20%)	4 (80%)	0 (0%)	0 (0%)	2 (40%)	3 (60%)
Failure of retention material	5 (100%)	0 (0%)	0 (0%)	1 (20%)	2 (40%)	2 (40%)	1 (20%)	3 (60%)	1 (20%)	1 (20%)	1 (20%)	3 (60%)
Total variables	44 (97.7%)	1 (2.2%)	0 (0%)	35 (77.7%)	6 (13.3%)	4 (8.8%)	19 (42.2%)	19 (42.2%)	6 (13.3%)	12 (26.6%)	15 (33.3%)	18 (40%)

+ : Superior .

± : Acceptable.

- : Inferior.

N: Number of subjects

Table 4: Descriptive statistics for the clinical performance evaluation of the four types of retainers after one year post-insertion using observed numbers and percentage of occurrence.

	Clear Advantage Series II Durable invisible retainer N=5			Clear Advantage Series I standard invisible retainer N=5			Hawley retainer N=5			Fixed bonded lingual retainer N=5		
	+	±	-	+	±	-	+	±	-	+	±	-
Versatility	5 (100%)	0 (0%)	0 (0%)	2 (40%)	1 (20%)	2 (40%)	1 (20%)	3 (60%)	2 (40%)	2 (40%)	2 (40%)	1 (20%)
Aesthetic	5 (100%)	0 (0%)	0 (0%)	4 (80%)	1 (20%)	0 (0%)	3 (60%)	1 (20%)	1 (20%)	5 (100%)	0 (0%)	0 (0%)
Speech	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	4 (80%)	1 (20%)	0 (0%)	0 (0%)	3 (60%)	2 (40%)
Retention	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	1 (20%)	2 (40%)	2 (40%)	3 (60%)	1 (20%)	1 (20%)
Bad taste and odor	3 (60%)	1 (20%)	1 (20%)	3 (60%)	1 (20%)	1 (20%)	0 (0%)	3 (60%)	2 (40%)	0 (0%)	2 (40%)	3 (60%)
Caries risk (Hygienic)	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	1 (20%)	4 (80%)	0 (0%)	1 (20%)	1 (20%)	3 (60%)
Soft tissue irritability	5 (100%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	1 (20%)	2 (40%)	2 (40%)	0 (0%)	2 (40%)	3 (60%)
Construction Time	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Chair- side time	5 (100%)	0 (0%)	0 (0%)	1 (20%)	2 (40%)	2 (40%)	1 (20%)	3 (60%)	1 (20%)	0 (0%)	1 (20%)	4 (80%)
Failure of retention material	5 (100%)	0 (0%)	0 (0%)	1 (20%)	1 (20%)	3 (60%)	1 (20%)	2 (40%)	2 (40%)	0 (0%)	1 (20%)	4 (80%)
Total variables	43 (95.5%)	1 (2.2%)	1 (2.2%)	31 (68.8%)	6 (13.3%)	8 (17.7%)	13 (28.8%)	20 (44.4%)	12 (26.6%)	11 (24.4%)	13 (28.8%)	21 (46.6%)

+ : Superior .

± : Acceptable.

- : Inferior.

N: Number of subjects

Table 5: Comparisons of the total variables of the clinical performance among the four types of retainers at different times using chi square

			CII and CI		CII and HR		CII and FR		CI and HR		CI and FR		HR and FR	
			x ²	Sig.	x ²	Sig.	x ²	Sig.	x ²	Sig.	x ²	Sig.	x ²	Sig.
At time of insertion	Total variables	+	0.000	NS	9.521	HS	13.564	VHS	9.521	HS	13.564	VHS	0.472	NS
		±	0.000	NS	0.000	NS	0.250	NS	0.000	NS	0.250	NS	0.250	NS
		-	0.000	NS	16.663	VHS	17.64	VHS	16.663	VHS	17.640	VHS	0.022	NS
After 3months post- insertion.	Total variables	+	0.842	NS	10.592	HS	14.000	VHS	5.666	S	8.332	HS	0.290	NS
		±	4.454	S	13.760	VHS	18.066	VHS	3.570	NS	0.726	NS	1.124	NS
		-	0.332	NS	6.400	S	15.210	VHS	4.454	NS	12.800	VHS	3.000	NS
After 6 months post- insertion	Total variables	+	1.024	NS	9.920	HS	18.284	VHS	4.840	S	11.254	VHS	1.580	NS
		±	3.070	NS	16.200	VHS	12.250	VHS	3.380	NS	3.856	NS	0.470	NS
		-	4.000	S	7.000	HS	18.000	VHS	0.818	NS	8.908	S	4.840	S
After 1 year ost-insertion	Total variables	+	1.944	NS	16.070	VHS	18.962	VHS	7.362	HS	9.522	HS	0.166	NS
		±	3.570	NS	17.190	VHS	10.284	VHS	7.338	NS	2.578	NS	1.484	NS
		-	5.444	S	9.306	HS	18.180	VHS	0.800	NS	5.826	S	2.454	NS

CII: Clear Advantage Series II Durable invisible retainer. **HR: Hawley retainer.**
 CI: Clear Advantage Series I standard invisible retainer. **FR: Fixed bonded lingual retainer.**
 + : Superior . ± : Acceptable. - : Inferior. **N: Number of subjects.**
NS: Non-significant (P>0.05) . S: Significant (P< 0.05). HS: Highly significant (P<0.01).
VHS: Very highly significant (P < 0.001)
X²: Chi square. Degree of freedom=1.

Table 6: Comparisons of the total time and total variables of the clinical performance among the four types of retainers using chi square

			CII and CI		CII and HR		CII and FR		CI and HR		CI and FR		HR and FR	
			x ²	Sig.	x ²	Sig.	x ²	Sig.	x ²	Sig.	x ²	Sig.	x ²	Sig.
Total time	Total variables	+	2.890	NS	45.440	VHS	64.500	VHS	26.380	VHS	42.020	VHS	2.141	NS
		±	7.810	S	38.360	VHS	24.920	VHS	4.720	NS	6.200	NS	1.940	NS
		-	7.200	NS	39.180	VHS	68.760	VHS	17.500	VHS	42.660	VHS	6.920	NS

CII: Clear Advantage Series II Durable invisible retainer. **HR: Hawley retainer.**
 CI: Clear Advantage Series I standard invisible retainer. **FR: Fixed bonded lingual retainer.**
 + : Superior . ± : Acceptable. - : Inferior. **N: Number of subjects.**
NS: Non-significant (P>0.05) . S: Significant (P< 0.05). HS: Highly significant (P<0.01).
VHS: Very highly significant (P < 0.001)
X²: Chi square. Degree of freedom=3.