Original Article

A retrospective randomized double-blind comparison study of the effectiveness of Hawley vs vacuum-formed retainers

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ABSTRACT

Objective: To compare Hawley with vacuum-formed retainers.

Materials and Methods: Eighty-two patients who had received treatment with upper and lower fixed appliances were randomly assigned either a Hawley or a vacuum-formed retainer. Study models were fabricated for each patient on day of debond and 2 months, 6 months, and 12 months after debond. Using a specially constructed pantograph, four variables were measured for each set of models at each of these time periods. These were upper and lower intermolar widths, intercanine widths, arch length, and a modified Little's index of irregularity. Method error was determined by repeating the measurements on 10 sets of models.

Results: For each of the variables under test and at each of the four time periods, there were no statistically significant differences ($\alpha = .05$) between each of the two retainers, vacuum-formed and Hawley.

Conclusion: The degree of relapse that is likely to occur following a course of fixed appliance therapy is unlikely to be affected by the choice of retainer, vacuum-formed or Hawley. Therefore, when deciding on the type of retainer to be fitted following fixed appliance therapy, other factors such as cost may play a more significant role. (*Angle Orthod.* 2011;81:404–409.)

KEY WORDS: Retainers; Retention; Hawley; Vacuum formed

INTRODUCTION

It has been shown by a number of long-term studies[1–3] that following a course of orthodontic treatment, relapse occurs in approximately 70% of cases. Some of this will be due to orthodontic relapse, and some will be due to normal changes with time, such as continued facial growth. The problem for the orthodontist is that not only is it impossible to predict which cases will undergo relapse, but it is also impossible to predict the degree to which this will occur. Relapse is unrelated to factors such as original incisor or molar classification, extractions,[4,5] or the degree of tooth movement.[4,6–9]

Not only is it difficult to predict which cases will require retention, but there is also currently no consensus on the amount or duration of retainer wear or indeed which type of retainer to use. Patients can be provided with either fixed or removable appliances, and various studies have investigated the effectiveness of each. A recent investigation found multistrand bonded retainers to be more effective in maintaining tooth position than single-strand wires.[10] A separate study investigating the effectiveness of bonded multistrand lingual retainers found them to be no more effective in retaining tooth position than a removable Hawley-type retainer.[11]

In recent years, vacuum-formed retainers have become increasingly popular and for a number of reasons, but principally due to ease fabrication, improved esthetics, and reduced cost. Purported disadvantages of vacuum-formed retainers include occlusal wear of the appliance with subsequent cracking in the longer term,[12] along with reduced vertical settling. In terms of their effectiveness, a previous randomized controlled trial found vacuum-formed retainers to be as effective as Hawley retainers

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Table 1. Sample Summary

	Male	Female	Total
Total number of cases			82
Hawley retainer cases	16	26	42
Vacuum-formed retainer cases	13	27	40
Average age at debond, y	14.9	14.9	SD = 2.7
Median time between debond and 2-mo data point, d			63
Median time between debond and 6-mo data point, d			192
Median time between debond and 12-mo data point, d			366

in maintaining incisor alignment,[13] although it has been suggested that they are not able to maintain arch expansion as well as a Hawley.[14]

The aim of the current study was to compare the effectiveness of vacuum-formed and Hawley retainers in maintaining arch width as well as incisor alignment.

MATERIALS AND METHODS

One hundred seventy consecutive orthodontic patients completing a course of upper and lower fixed appliance therapy using the straight wire appliance at the Orthodontic Department of North Hampshire Hospital, Basingstoke, United Kingdom, were initially entered into this study. The exclusion criteria were the following:

- cases requiring bonded retainers,
- cases requiring adjunctive procedures (eg, pericision or interdental stripping), and
- any case requiring orthognathic surgery.

At the time of recruitment, it was not routine practice to obtain written consent for participation in the trial; only verbal consent was required. Following appliance removal and enamel cleanup, alginate impressions were taken. Stone working models and plaster study models were poured within one to two hours by one technician.

The retainer type for each case was randomly allocated by the technician using a single throw of a dice. Even numbers indicated upper and lower Hawley retainers, and odd numbers indicated vacuum-formed retainers.

All were constructed on working models poured from the original impressions before casting the study models using dental stone (Kaffir HXD, British Gypsum Limited, Loughborough, UK). The Hawley retainers were constructed to a standard design using Adams cribs on the first molars and a labial bow constructed in 0.7 mm stainless-steel wire. Self-curing orthodontic acrylic was used for the palate (Forestacryl Strong, Forestadent, Pforzheim, Germany). The vacuum-formed retainers were made using the Dentamid Dreve Druformat (model 2352, Dentamid, Germany) and Tru tain 0.030″ sheets (Rochester, Minn). All devices were made in the orthodontic department laboratory at the North Hampshire Hospital.

At the fitting appointment, all patients were instructed to wear the appliance full-time and to remove the appliance only for cleaning throughout the 12-month period of the study.

Each patient was reviewed 2, 6, and 12 months after debond, when new alginate impressions and occlusal records were taken for the construction of new study models using the same materials and facilities as previously.

All of the laboratory work was carried out in one laboratory by the same technician.

Of the 170 cases originally identified, only 82 complete record sets were available 12 months after debond: 42 in the Hawley retainer group, and 40 in the vacuum-formed retainer group (Table 1). This was mainly due to nonattendance at review appointments and less often due to patients losing or breaking retainers that had not immediately been repaired/replaced.

All measurements were made using a novel approach. Instead of trying to measure the distances under test using a digital caliper directly on the study model, it was decided to magnify the distances between the chosen reference points on the models using a simple pantograph. To aid point location, a microscope with crosshairs (Minolta 50 mm 1:17 fitted with a No1 extension tube and eyepiece, Konica-Minolta, Osaka, Japan) was at one end of the pantograph, whereas at the other end was a fine marker pen. Once a point was located on the model using the crosshairs, its position was plotted using the pen, holding the end of the pantograph onto plotting paper. Digital calipers were then used to measure the amplified distances directly from the plotting paper. Figure 1 shows the setup of the model beneath the Perspex table on which was placed the pantograph, microscope, and plotting paper.

All of the models were measured by a single researcher as follows:

1. The relevant landmarks were lightly marked on the models with a 0.5-mm lead-propelling pencil with the aid of 2.5× diopter magnifying loupes (GSC 460-351, Ann Arbor, Mich). Once marked, the points were not visible to the unaided eye but were visible with the pantograph microscope.
2. Each point was carefully compared visually between models to ensure the same point was marked on each tooth.

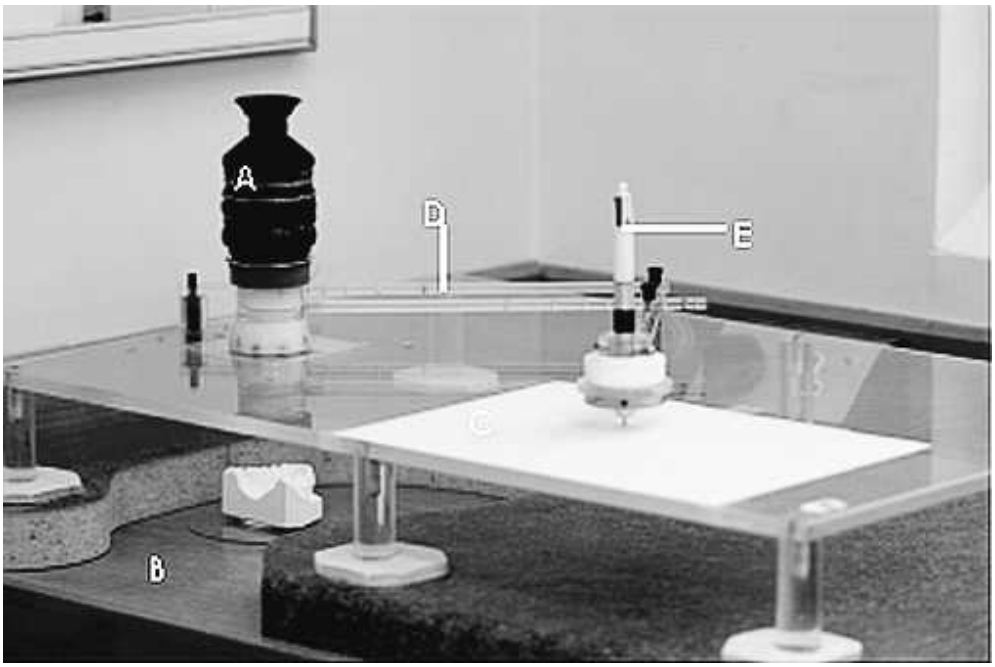

Figure 1. The pantograph. (A) Measuring microscope. (B) Measuring table. (C) Recording paper. (D) Pantograph arm. (E) Pen recorder.

3. The points marked were:

   (a) The midpoint on the mesial marginal ridge of all four first permanent molars. The mesial marginal ridge was chosen as it was easy to mark consistently and the same point could also be used for the arch length measurement.
   (b) The midpoint of mesial and distal marginal ridges of all canines and incisors.
   (c) The highest point of the cusp tips of the canines. Occasionally, the cusp tips of the canines were worn and presented as a small plateau. In this case, the center of the plateau as judged by the eye was used.

Using the pantograph and the above reference points, the upper intercanine width (UCW), lower intercanine width (LCW), upper intermolar width (UMW), lower intermolar width (LMW), modified Little's index for both the upper and lower incisors, and also the upper and lower arch lengths (UAL, LAL) were determined.

The UAL and LAL were determined by measuring from the mesial of the molar to the distal of the canine and then from the distal of the canine to the mesial of the central incisor on the same side. Adding these measurements to the measurements on the other side gave the resulting arch length. This method may allow any significant changes in arch length to be attributed to changes in the anterior or posterior segments.

Anterior irregularity was measured using a modified index as described by Little.[15] This index was modified as follows:

- Pencil points were marked on the distal and mesial incisal edges of the teeth while the single operator (Dr Barlin) was wearing loupes. These points were chosen so that they could be similarly positioned on each of the four models on the same tooth.
- The distance between these points for adjacent teeth was measured. This would include any spacing present as well as contact displacement.
- The same index was also applied to the upper labial segment teeth.

The 5 measurements obtained from the labial segments were added together, and the result was recorded as the index of irregularity.

In all cases, the measurements obtained were converted to true distances, by dividing each result by 5.05 (the magnification factor of the pantograph).

All four sets of study models (debond, 2 months, 6 months, and 12 months) were measured in this way for each of the 82 cases.

RESULTS

The data were analyzed using SPSS version 12 (SPSS, Chicago, Ill) and STATA version 8 (StataCorp LP, College Station, Tex) statistics packages. In each case, the level of significance was set at $\alpha = .05$. The residuals of the data were tested for normality using the Shapiro Francia test and in most instances were found to be nonnormal. Therefore, the Kruskal-Wallis nonparametric one way of variance was also used to assess whether there were statistically significant differences between the groups for each measure-

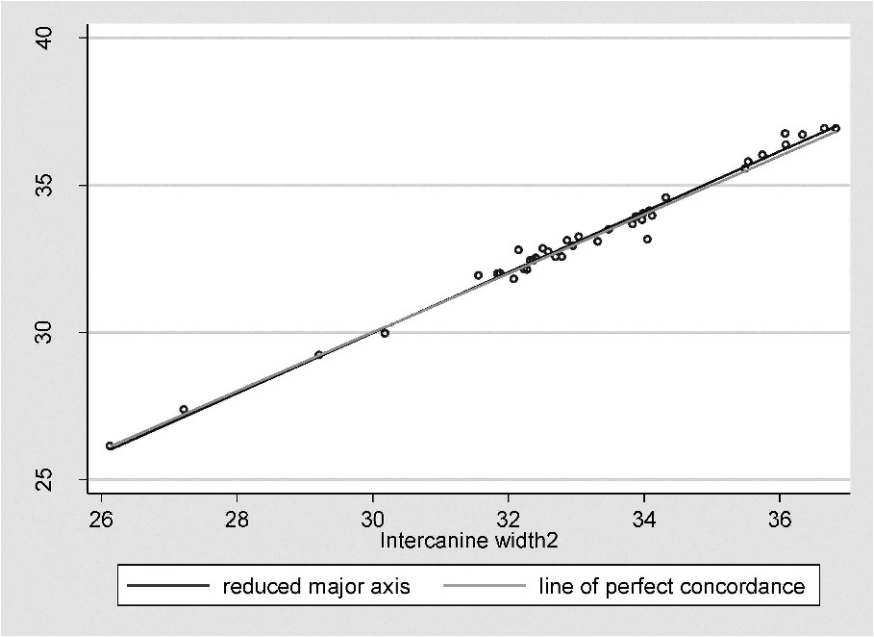

Figure 2. Lin's concordance correlation coefficient plot used to assess the repeatability and method error for the measurement of upper intercanine width (mm).

ment. In this way, the effect of both retainer and time was assessed, and in each case, the significance level was predetermined at the 5% level.

Taking each of the above in turn, to test for method and random errors, the upper intercanine widths of 40 cases were remeasured, and the differences between the two were assessed using Lin concordance[16,17] coefficients (Figure 2).

The clinical parameters measured for each of the models at debond and 2, 6, and 12 months after debond were the following:

- UCW and LCW,
- UMW and LMW,
- UAL and LAL, and
- upper irregularity index (Little) and lower irregularity index.

Taking each in turn, and beginning with the intercanine widths, it would seem there is little difference in intercanine width with each type of retainer and over the four time periods. Using the Kruskal-Wallis one-way analysis of variance (UCW, $P = .98$; LCW, $P = .74$) for each arch, it would appear there is no statistically significant effect of retainer type or time interval (Tables 2 and 3).

For the intermolar widths, the Kruskal-Wallis one-way analysis of variance once again showed that there appears to be no significant difference between the Hawley and vacuum-formed retainers (UMW, $P = .78$; LMW, $P = .99$; Tables 4 and 5) and over the four time periods.

Similarly with arch length, there was no statistically significant difference between the Hawley and vacuum-formed retainers with time in either the

Table 2. Kruskal-Wallis One-Way Analysis of Variance Investigating the Difference in Upper Intercanine Width Between Retainer Type at Each Time Interval in the Upper Arch

Retainer Type	Code	Time, mo	Arch	Obs	Mean Rank	$P > \chi^2$
Hawley	1	Debond	Upper	42	157.14	.98
Vacuum	2	Debond		40	167.20	
Hawley	3	2		42	166.18	
Vacuum	4	2		40	167.87	
Hawley	5	6		42	163.05	
Vacuum	6	6		40	165.91	
Hawley	7	12		42	151.12	
Vacuum	8	12		40	174.55	

Table 3. Kruskal-Wallis One-Way Analysis of Variance Investigating the Difference in Lower Intercanine Width Between Retainer Type at Each Time Interval in the Lower Arch

Retainer Type	Code	Time, mo	Arch	Obs	Mean Rank	$P > \chi^2$
Hawley	9	Debond	Lower	42	163.02	.74
Vacuum	10	Debond		40	169.29	
Hawley	11	2		42	166.23	
Vacuum	12	2		40	177.81	
Hawley	13	6		42	158.50	
Vacuum	14	6		40	175.50	
Hawley	15	12		42	140.42	
Vacuum	16	12		40	162.98	

Table 4. Kruskal-Wallis One-Way Analysis of Variance Investigating the Difference in Upper Intermolar Width Between Retainer Types at Each Time Interval in the Upper Arch

Retainer Type	Code	Time, mo	Arch	Obs	Mean Rank	$P > \chi^2$
Hawley	1	Debond	Upper	42	155.65	.78
Vacuum	2	Debond		40	182.81	
Hawley	3	3		42	160.75	
Vacuum	4	3		40	175.33	
Hawley	5	6		42	156.98	
Vacuum	6	6		40	167.21	
Hawley	7	12		42	148.19	
Vacuum	8	12		40	167.07	

Table 6. Kruskal-Wallis One-Way Analysis of Variance Investigating the Difference in Arch Length Between Retainer Type at Each Time Interval in the Upper Arch

Retainer Type	Code	Time, mo	Arch	Obs	Mean Rank	$P > \chi^2$
Hawley	1	Debond	Upper	42	164.80	1.00
Vacuum	2	Debond		40	164.48	
Hawley	3	3		42	168.35	
Vacuum	4	3		40	163.46	
Hawley	5	6		42	163.81	
Vacuum	6	6		40	163.38	
Hawley	7	12		42	160.93	
Vacuum	8	12		40	162.70	

upper ($P = 1.00$) or lower ($P = .31$) arches (Tables 6 and 7).

When considering the modified Little's index, there was again no difference between the Hawley and vacuum-formed retainers in either the upper ($P = .99$) or the lower arches ($P = .77$) over the four time periods (Tables 8 and 9).

DISCUSSION

There are various types of retainers available to the orthodontist, both removable and fixed, and it can be difficult to know how to advise patients with respect to type and wear. In an attempt to answer this question, a number of studies have been carried out in recent years that have investigated different aspects of retention. For example, Lindauer and Shoff[18] measured the changes in overbite, overjet, and Little's index with both Hawley and Essix-type of vacuum-formed retainers after 6 months and found no significant difference between the two. Similarly, Tibbets[19] compared the same two appliances over 6 months, but this time included intercanine width, intermolar width, and arch length. Again, no differences were observed between the two types of retainers.

A more recent trial also studied the effectiveness of Hawley and vacuum-formed retainers in maintaining arch width, rotations, and incisor alignment over a 6-month period.[13] The protocol required patients to wear the retainers full-time for 3 months followed by nights only for 3 months. In terms of incisor alignment, the vacuum-formed retainer was more effective than the Hawley retainer, particularly in the lower incisor region, although there was still a question mark over the clinical significance of the observed difference.

Another trial investigating the use of Hawley retainers worn full-time for 12 months vs Hawley retainers worn 6 months full-time, followed by 6 months part-time, concluded there was again no difference in the observed Little's index with either regimen.[20] Using a similar protocol, but this time looking at vacuum-formed retainers worn either full- or part-time, a further study found there was no statistically significant difference between full- and part-time wear with respect to Little's index.[21]

The current study investigating Hawley and vacuum-formed retainers over 12 months of full-time wear also indicates there to be no statistically significant difference between the two types of retainers with respect to arch widths, arch length, and Little's index, in either the upper or lower arches.

The most recent Cochrane review[22] concluded there was insufficient evidence on which to base the clinical practice or retention in orthodontics. The present study has added to this evidence but would seem to indicate that vacuum-formed retainers are as effective as Hawley retainers in maintaining the four parameters under test. If this is the case, then other factors such

Table 5. Kruskal-Wallis One-Way Analysis of Variance Investigating the Difference in Lower Intermolar Width Between Retainer Types at Each Time Interval in the Lower Arch

Retainer Type	Code	Time, mo	Arch	Obs	Mean Rank	$P > \chi^2$
Hawley	9	Debond	Lower	42	167.26	.99
Vacuum	10	Debond		40	158.40	
Hawley	11	3		42	163.99	
Vacuum	12	3		40	171.26	
Hawley	13	6		42	167.87	
Vacuum	14	6		40	161.40	
Hawley	15	12		42	157.71	
Vacuum	16	12		40	164.25	

Table 7. Kruskal-Wallis One-Way Analysis of Variance Investigating the Difference in Arch Length Between Retainer Type at Each Time Interval in the Lower Arch

Retainer Type	Code	Time, mo	Arch	Obs	Mean Rank	$P > \chi^2$
Hawley	9	Debond	Lower	42	154.90	.31
Vacuum	10	Debond		40	180.45	
Hawley	11	3		42	152.36	
Vacuum	12	3		40	186.68	
Hawley	13	6		42	149.13	
Vacuum	14	6		40	177.98	
Hawley	15	12		42	144.87	
Vacuum	16	12		40	168.94	

Table 8. Kruskal-Wallis One-Way Analysis of Variance Investigating the Difference in Little's Index Between Retainer Type at Each Time Interval in the Upper Arch

Retainer Type	Code	Time, mo	Arch	Obs	Mean Rank	$P > \chi^2$
Hawley	1	Debond	Upper	42	167.07	.99
Vacuum	2	Debond		40	168.98	
Hawley	3	3		42	161.62	
Vacuum	4	3		40	163.82	
Hawley	5	6		42	157.18	
Vacuum	6	6		40	165.16	
Hawley	7	12		42	155.33	
Vacuum	8	12		40	173.57	

Table 9. Kruskal-Wallis One-Way Analysis of Variance Investigating the Difference in Little's Index Between Retainer Type at Each Time Interval in the Lower Arch

Retainer Type	Code	Time, mo	Arch	Obs	Mean Rank	$P > \chi^2$
Hawley	9	Debond	Lower	42	169.15	.77
Vacuum	10	Debond		40	143.01	
Hawley	11	3		42	167.40	
Vacuum	12	3		40	156.38	
Hawley	13	6		42	167.21	
Vacuum	14	6		40	157.50	
Hawley	15	12		42	180.63	
Vacuum	16	12		40	169.09	

as esthetics, ease of fabrication, and cost should be taken into account when deciding on the most appropriate type of retainer. A factor that will influence both cost and effectiveness, and which was not recorded in the present study, is the likelihood of breakage of either type of retainer. Previously, vacuum-formed retainers have been reported to break less often than Hawley retainers.[23] Further studies on different wear regimens with vacuum-formed retainers are still required.

CONCLUSIONS

- There is no statistical or clinically significant difference in the measured arch width, arch length, or modified Little's index over a 12-month period between Hawley and vacuum-formed retainers when worn full-time.
- Therefore, other factors may be more important when deciding on the most appropriate form of retainer to be used following a course of orthodontic treatment.

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