

Comparison of speech alteration on wearing of Hawley's and vacuum formed retainer: A randomized controlled trial

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Abstract:

Objectives: To investigate and compare the effect on speech alteration, in orthodontic patients wearing Hawley's and vacuum formed retainers; by an objective acoustic analysis of vowels and consonants over an extended period of time.

Materials and Methods: 66 subjects were randomly divided by block randomization and 5 subjects were failed to follow up, therefore two groups were: [1] The Hawley's retainer (31 subjects) and [2] the vacuum formed retainer group (30 subjects). The subjects were instructed to pronounce vowels [a, e, i, o, u] and consonants [t, d, n, s, z, m, n, c, h, g] & recorded through microphone, at (i) Before wearing retainers[T0], (ii) Immediately after delivering retainers[T1], (iii) At 24 hours[T2], (iv) At 1 week[T3], (v) At 1 month[T4], and (vi) At 3 months[T5]. The recorded data were analyzed later by using a frequency analyzing software.

Results: Statistically significant changes were observed with vowels (/i/, /u/) & consonants (/t/, /d/, /m/). In vacuum formed retainer group articulation of /i/, /u/, /t/, and /d/ were most affected(p<0.05); while in Hawley's retainer group /i/, /u/, /t/ and /m/ were significantly impaired(p<0.05).

Conclusion: Sounds such as /i/, /u/, /t/, and /d/ for the Hawley's retainer group and /i/, /u/, /t/, /d/, and /m/ for vacuum formed retainer group showed significant alteration. A comparison of the HR group with the VFR group revealed that the changes in articulation were more significant in the Hawley's retainer group.

Key Word: Speech alteration, Hawley's retainer, vacuum formed retainer, Vowels, Consonants

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I. Introduction

Retention is a one of the most important phases of orthodontic treatment. During this phase, the reorganization of the periodontal ligament occurs over the first three to four months. After orthodontic tooth movement, the teeth have a tendency to return to their pre-treatment positions. Retainers are used to prevent the teeth from returning to their former positions until gingival and periodontal reorganization is completed. Retainers may be (1) fixed to the dentition, such as a bonded wire or (2) removable, such as a Hawley's or Essix/ vacuum formed retainers.

The two most commonly used removable retainers are the Hawley's retainer¹ and the vacuum-formed retainer². The advantages of Hawley's retainer include the ability to improve the posterior contacts and durability of the appliance. The disadvantages associated with the same include, interference with settling and needful patient compliance. Essix/vacuum formed retainers, are clear thermoplastic appliances, and they are more esthetic from a patients' perspective, and for this reason may be worn more willingly than Hawley's retainers.

Speech will be affected by any device that affects the movements of soft and hard oral tissues. Hence, changes in articulation caused by retainers would have significant effect on patient compliance during retention treatment. Little is known about the phonetic influence of orthodontic retention appliances. In this study, the effects on speech impairment by Hawley's retainer and vacuum-formed retainer were investigated and compared using objective acoustic analysis.

The aim of this study was to investigate and compare the effect on speech alteration, in orthodontic patients wearing Hawley's retainer and vacuum formed retainers; by an objective acoustic analysis of vowels and consonants over a 6 months' period of time.

II. Material and Methods

This is a single centre randomized, parallel group, active control trial. After approval from the research and ethical committee, 66 subjects were included in this study. Trial had been registered in the clinical trials

registry-India (CTRI). The registration number for this trial was CTRI/2020/04/024486. The block randomization was done. 5 subjects had been dropped out as they failed to come for the follow up at given time interval. The remaining, 61 subjects were divided in two groups randomly: [1] The Hawley's retainer (Group 1: 31 subjects) and [2] the vacuum formed retainer group (group 2: 30 subjects). Subjects who had completed their orthodontic treatment, having age above 18 years of age and gave consent for the proposed study were included in this study. Patients with Cleft lip or cleft palate; patients who had undergone surgical correction of the jaws; patients who had hearing and speech disorders & patients who had systemic diseases were excluded(**Table-1**). The informed consent was taken by each participant. Hawley's retainers (**figure-1, figure-2**) were constructed of cold cure acrylic base plate with uniform thickness of 2 mm, Adam's clasps on first molar, and a short labial bow. Vacuum formed retainers (**figure-3, figure-4**) of 2 mm thickness, were constructed on Atxin, AX-KZ vacuum former.

Table 1: Inclusion & exclusion criteria

Inclusion criteria	Exclusion criteria
1. Patients who have completed their orthodontic treatment	1. Patients with Cleft lip or cleft palate
2. Patients having age above 18 years of age.	2. Patients who had undergone surgical correction of the jaws
3. Patients who gave consent for the proposed study	3. Patients who had hearing and speech disorders
4. Patients who were systemically healthy	4. Patients who were suffering from serious periodontitis

Figure 1 - Maxillary Hawley's retainer



Figure 2- Mandibular Hawley's retainer

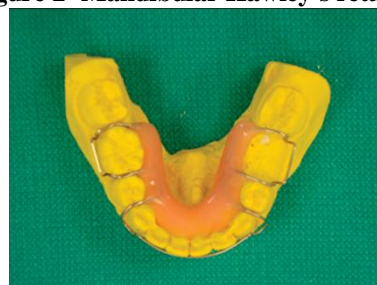


Figure 3-Maxillary Vacuum formed retainer



Figure 5-Mandibular Vacuum formed retainer



The patients of both the groups were instructed to wear the retainers 24 hours a day for 6 months, other than while eating and brushing their teeth. The subjects were instructed to pronounce vowels [a, e, i, o, u] and consonants [t, d, n, s, z, m, n, c, h, g] at following intervals of time (i)before delivery of retainer, (ii) immediately after delivering retainer, (iii) after 24 hours, (iv) after 1 week, (v) after 1 month, (vi) after 3 months, and (vii) after 6 months. These vowels and consonants were recorded through microphone (Sony ECM-3 microphone) positioned 10cm away from the participants' mouths. The recorded data were analyzed by using a frequency analyzing software (Vuche labs, India). All testing was conducted in a closed room with minimum noise.

Statistical analysis

Observations and results are divided into two parts: Statistical analysis for (1) Vacuum formed retainer group & (2) Hawley's retainer group. The data was transformed from survey form to computer. The job of data entry, validity checks and formation of desired results was done using statistical package of social sciences (SPSS version 21). The level of statistical significance was set at $p \leq 0.05$. T represents various time points. T0 indicates before wearing retainers; T1, immediately after wearing both upper and lower retainer; T2, 24 hours later; T3, 1 week later; T4, 1 month later; T5, 3 months later; T6, 6 months later

III. Result

In both the HR and VCFR group the sounds impaired were mainly /i/, /u/, /t/, /d/, /m/, and /h/.

1. The results of speech alteration by Vacuum formed retainer are as follow:

Table 2 shows mean frequencies with standard deviation at T1, T2, T3, T4, T5 & T6 respectively. It is seen in frequency distribution graph at T0, T1(**table 3**), that frequencies of all the vowels and consonants decreased immediately after delivery of retainer, which returned back to normal or near to normal within 1 month for /a/, /e/, /n/, /s/, /z/, /c/ & /g/, but remained decreased even more time for /i/, /u/, /d/, /t/, /m/and /h/.

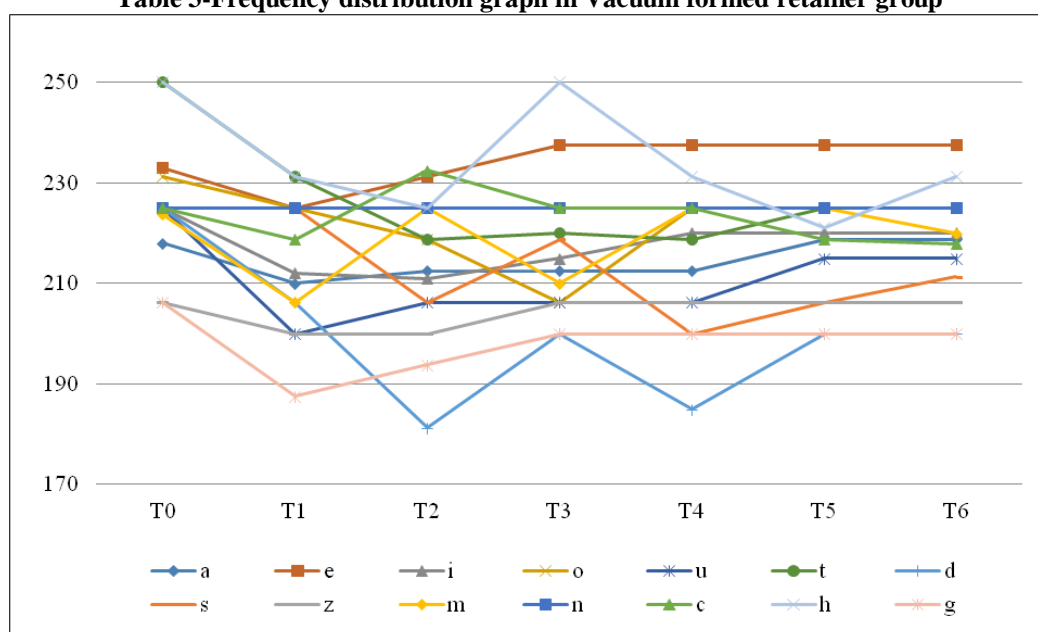
Table 2: Mean frequencies (Hzs) while wearing Vacuum formed retainer

	T0	T1	SD	T2	SD	T3	SD	T4	SD	T5	SD	T6	SD
i	225	212	9.192	211	9.899	215	7.0710	220	3.535	220	3.535	220	3.535
u	225	200	17.677	206.25	13.258	206.25	13.258	206.25	13.258	215	7.071	215	7.071
t	250	231.25	13.258	218.75	22.097	220	21.213	218.75	22.097	225	17.677	225	17.677
d	225	206.25	13.258	181.25	30.935	200	17.677	185	28.284	200	17.677	200	17.677
m	223.75	206.25	12.374	225	0.883	210	9.722	225	0.883	225	0.883	219.91	2.715
h	250	231.25	13.258	225	17.677	250	0	231.25	13.258	221.09	20.442	231.25	13.258

In vacuum formed retainer group as shown in **table 3**, /a/, /e/, /n/, /s/, /z/, /c/ and /g/ were not impaired much. The frequencies of /a/ and /e/ decreased for 3 weeks and 1 week respectively after delivery of retainer, but no statistically significant differences were found after 3 weeks. The frequency of /h/ reduced immediately after delivery of retainer from 250Hzs to 231Hzs and remained low even after 6 months significantly.

Articulation of /d/ was most affected. Its frequency reduced by 20Hzs immediately after 24 hours (SD=13.258), and decreased even more significantly (SD=30.935) at T2 and remained low till T6. The frequency was recorded at 200Hzs even after 3 months & remained same after 6 months. In the frequency distribution graph (**table 3**), /d/ (dark blue line) indicated the changes in its articulation. Articulation of /t/ was 2nd most affected in VCFR group. Its frequency reduced immediately after delivery and after 24 hours (SD=22.097). The mean frequency was 250Hzs without retainer, which remained low at 225Hzs even after 3months which was significant (SD=17.677). The yellow colour line for /t/ indicated that at T5 there was increase in frequency, but it was less than T1 (**table 3**). A significant impairment was noted for/h/, which was 250Hzs without retainer and remained at 231Hzs (SD=13.258) while wearing both maxillary and mandibular VCFRs.

Table 3-Frequency distribution graph in Vacuum formed retainer group



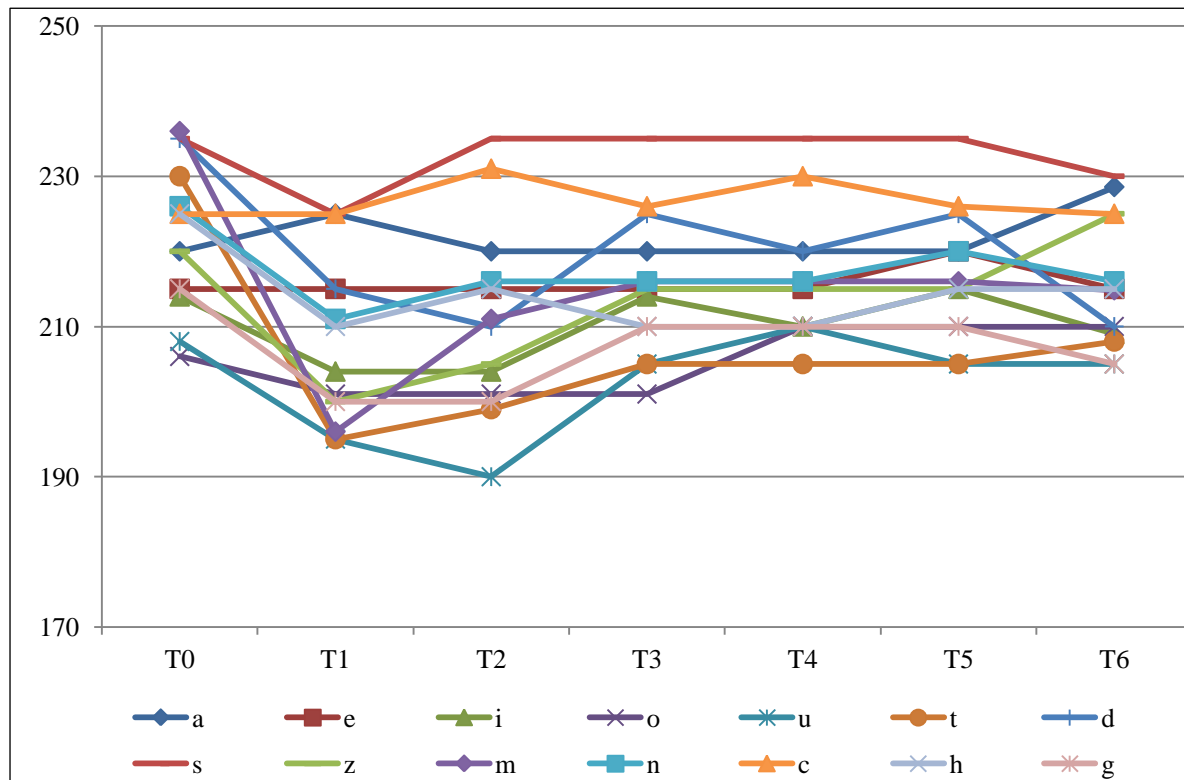
The frequency of /u/ reduced by 25Hzs with SD of 17.677Hzs immediately after delivery of retainer which was significant and remained low even after 1 months (SD=13.258Hzs); while for /i/, the frequency decrease immediately after delivering retainer (SD= 9.192), was statistically significant, and this change was significant till T3 (SD=7.071). For the articulation of /m/, significant distortion was noted at T1 (SD=12.374Hzs) and its articulation reverted back after 3weeks. With /s/, there was significant reduction of 19Hzs (SD=13.258) till T5 and at T6 it reduced to 211Hzs, 14Hzs less than T0. But, there were no significant changes observed in Hawley's retainer group for articulation of /s/.

2. The results of speech alteration by Hawley's retainer group are as follow:
 In Hawley's retainer group as shown in **table 4** and frequency distribution graph (**table 5**), frequency of /a/, /e/, /z/, & /c/ reduced initially, but after T3 it had been observed that their frequencies started returning back to initial frequencies. There were no significant changes observed from T3 to T6 for /a/ (SD=0), /e/ (SD=0), /z/ (SD=3.535), and /c/ (SD=3.535). For Hawley's retainer group, frequencies of /t/ and /m/ were impaired significantly (**Table 4**). **Table 5** showed that frequency of all the vowels and consonants decreased immediately after delivery of retainer, which returned back to initial frequencies for /a/, /e/, /o/, /n/, /s/, /z/, /c/ & /g/, but it decreased even more for /d/, /t/, /u/ and /i/ after 1week of wearing retainer.

Table 4: Mean frequencies (Hzs) while wearing Hawley's retainer

	T0	T1	SD	T2	SD	T3	SD	T4	SD	T5	SD	T6	SD
i	214	204	7.071	204	7.071	214	0	210	2.828	215	0.707	209	3.535
u	208	195	9.192	190	12.727	205	2.121	208	0	205	2.121	205	2.121
t	230	195	24.748	199	21.920	205	17.677	205	17.677	205	17.677	208	15.556
d	235	215	14.142	210	17.677	225	7.071	220	10.606	225	7.0710	210	17.677
m	236	196	28.284	211	17.677	216	14.142	216	14.142	216	14.142	214.82	14.972
h	225	210	10.606	215	7.0710	210	10.606	210	10.606	215	7.071	215	7.071

Table 5-Frequency distribution graph in Hawley's retainer group



The consonants which were most affected on wearing Hawley's retainer were /t/ and /m/ in our study. As it can be seen in frequency distribution graph from T0 to T6 (**table 3**) the mean frequency of /t/ was 230 without retainer, which reduced to 195Hzs immediately after delivery of retainer (SD=24.748Hzs) and after 3 months the frequency was 205Hzs, which showed that the patient did not adapt to Hawley's retainer even after 3months to pronounce /t/ (SD=17.577Hzs). The frequency of /m/ was 2nd most affected in this group. For /m/, frequency was 236Hzs without retainer and significantly reduced to 196Hzs immediately after delivery of Hawley's retainer (SD=28.284Hzs). Results also showed that patient might have adapted to pronounce /m/ as it's frequency returned back to 211Hzs after 24 hours, but it was still less than the frequency measured without retainer even after 6 months(SD=14.972Hzs). In distortion related to /h/ significant changes were noted from T1 to T4 (SD=10.606Hzs) and as patients adapted to the retainer there were less significant changes at T5 and T6 (SD=7.071Hzs)

For vowels, significant distortion was noted immediately after delivery of Hawley's retainer (SD=7.071Hzs) and the change was significant till T2. The vowel which was affected most was /u/. There were significant changes in its frequency noted at T1 and T2 (SD=12.727Hzs).

Table 6 depicts the descriptive statistics for different observation periods for the two compared groups, and that is for vowels and consonants separately. It is seen that for the first period that is w/o retainer the average value is higher for the vowels of Hawley's group whereas in case of consonants, the average value is almost similar for both Hawley's and Vacuum retainers. For the period 'immediately after delivery' the average value is higher for the vacuum retainers in case of both vowels and consonants. In case of vowels, it is found that the average value for the Hawley's group is lesser than the other one for all the six periods. On the other hand, in case of consonants, it is seen that the average values for the Hawley's group is higher than the vacuum retainers, for all the remaining four periods.

Table 6: Descriptive statistics for different Observation periods with respect to two groups i.e. Hawley's and Vacuum Retainers

		Vowels			Consonants		
Periods	Groups	Mean	Std. Deviation	Std. Error Mean	Mean	Std. Deviation	Std. Error Mean
w/o retainer	Hawley's	212.0000	27.72634	5.54527	226.8889	27.39212	4.08338
	Vacuum	225.0000	15.43033	3.28976	225.8333	16.92420	2.82070
immediately after delivery	Hawley's	206.6000	27.33740	5.46748	210.7778	34.44290	5.13444
	Vacuum	221.5909	11.68906	2.49212	214.5833	18.29813	3.04969
after 24hrs	Hawley's	206.0000	29.68586	5.93717	216.3333	30.32776	4.52099
	Vacuum	219.3182	15.29826	3.26160	211.9444	18.37225	3.06204
after a week	Hawley's	211.0000	25.73908	5.14782	219.1111	26.29139	3.91929
	Vacuum	222.7273	18.75451	3.99847	219.8611	20.23032	3.37172
after a month	Hawley's	213.0000	28.06243	5.61249	220.7778	29.38683	4.38073
	Vacuum	220.4545	16.61247	3.54179	213.8889	16.30561	2.71760
after 3 months	Hawley's	214.0000	28.93959	5.78792	222.4444	28.55661	4.25697
	Vacuum	222.7273	15.25398	3.25216	215.9722	14.82370	2.47062

Table 7 shows the difference in the effects of Hawley's & Vacuum formed retainers on the frequencies of vowels and consonants. This table shows that there lies a statistically significant difference in the effect of Hawley's and Vacuum formed retainers in case of the vowels /i/ and /u/, at 5% level of significance. In addition, in case of the consonants the mean differences are statistically significant, for /t/ and /d/. This table also depicts that, in case of vowels Hawley's retainer is more effective than the other one for all the periods in which the results are statistically significant (i.e. p-value < 0.05).

Table 7: Comparison between the effects of Hawley's & Vacuum formed retainer on the frequencies of vowels and consonants using unpaired sample t-test

Periods	VOWELS					CONSONANTS				
	t	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference		t	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
				Lower	Upper				Lower	Upper
w/o retainer	-1.95	0.04	-13.00	-26.44	0.44	0.20	0.84	1.06	-9.33	11.44
immediately after delivery	-2.38	0.02	-14.99	-27.65	-2.33	-0.60	0.55	-3.81	-16.47	8.85
after 24hrs	-1.89	0.04	-13.32	-27.49	0.85	0.76	0.45	4.39	-7.06	15.84
after a week	-1.76	0.03	-11.73	-25.12	1.67	-0.14	0.89	-0.75	-11.34	9.84
after a month	-1.09	0.28	-7.45	-21.25	6.34	1.26	0.21	6.89	-4.00	17.78
after 3 months	-1.27	0.21	-8.73	-22.60	5.15	1.23	0.22	6.47	-3.98	16.92

Table 8 shows that the difference in the mean effects of Hawley's and Vacuum retainer on the vowels separately the mean differences are statistically significant, for /i/, /u/, /t/ and /d/ at 5% level of significance; distortion related to /m/, though present, was not statistically significant

Table 8: Comparison between the effects of Hawley's & Vacuum formed retainer on the frequencies of the /i/, /u/, /t/, /d/, and /m/ using unpaired sample t-test

Periods/	w/o retainer			Immediately after delivery			after 24 hours		
vowels	t	p-value	Mean Diff	t	p-value	Mean Diff	t	p-value	Mean Diff
i	-1.06	.032*	-21.00	-1.06	.032*	-21.00	-1.06	.032*	-21.00
u	-1.44	.019*	-10.00	-2.17	.007*	-18.25	-1.44	.019*	-10.00
t	.7071	.502*	-18.75	2.8870	.020*	12.556	1.4189	.022*	13.920
d	-1.42	.20*	-17.50	2.3214	.024*	3.877	1.8043	.108*	15.934
m	0.8873	.400*	13.807	0.7424	.479*	13.807	1.7687	.114*	7.916
Periods/	after a week			after a month			after 3 months		
vowels	t	p-value	Mean Diff	t	p-value	Mean Diff	t	p-value	Mean Diff
i	-1.60	.057*	-11.00	-1.04	.033*	-15.00	-.52	.062*	-10.00
u	-1.74	.012*	-13.75	1.44	.019*	10.00	.88	.041*	5.00
t	3.1205	.002*	4.807	2.4295	.018*	5.660	2.5298	.021*	7.906
d	2.9361	.018*	8.515	2.5908	.032*	13.509	2.9361	.018*	8.515
m	0.5828	.576*	-6.00	0.8742	.407*	-9.00	0.8742	.407*	-9.00

*p ≤ 0.05

From above explained results it was concluded that there was significant alteration in articulation of /t/ and /d/ in VCFR group; while in HR group, articulation of /t/ and /m/ was significantly impaired.

IV. Discussion

Retainers are routinely used by patients for 6–12 months after orthodontic treatment has been completed because remodeling of the soft and hard tissues occurs during this period.³ Hawley and Vacuum formed/ Essix retainers are the two most commonly used removable retainers. Any oral appliances can usually affect tongue posture and palatal volume. Despite the fact that removable appliances are more comfortable but they do disturb speech.⁴

Among vowels, the /i/ and /u/ sounds demonstrated significant differences when wearing HR (Hawley's retainer). During pronunciation while wearing the HR, the primary position of the tongue reached maxillary acrylic base plate, which in turn moved to a lower position, resulting in the decrease of frequency.⁵ Unlike the HR group, the frequency of /i/ in the VFR group showed a smaller change, which could be because the thermoplastic material did not cover palate, as well as it was thinner than that of HR.

While producing the /t/ sound, the tongue is located in a higher position, and this position resulted in the contact of the tongue with the acrylic base plate of the maxillary retainer, that leads to decrease in frequency. As vacuum formed retainer covers the tooth labially and palatally, it impairs /s/ pronunciation. Normally, when the /s/ sound is pronounced, the front of the tongue is placed close to the tooth ridge; i.e. tip of the tongue should be close to the palatal surface of the anterior teeth.

Mavis Emel Kulak Kayikci et al⁶ assessed (1) whether Hawley's retainers cause speech disturbance and also (2) time taken to adapt to Hawley's retainers with objective and subjective tests. They observed that retainer causes temporary changes in speech and adaptation period can last for 1 week or for as long as 3 months. We observed the significant changes lasted for 3 to 6 months. After wearing Hawley's retainers, patients showed statistically significant speech disturbances of consonants [s,] and [z]; while our study showed disturbances in frequencies of /t/ and /m/. Related to the vowels, significant changes were recorded with [i] and [u], which is similar to our study.

Junyu Chen et al⁵ showed the scientific evidence and mechanism of the speech difficulties caused by orthodontic appliances. According to it, the /i/, /a/, and /e/ vowels as well as /s/, /z/, /l/, /t/, /d/, /r/, and /ʃ/ consonants could be distorted by appliances. Though most speech impairments could return to normal within weeks, speech distortion of the /s/ sound might last for more than 3 months; while in our study the /i/ and /u/ vowels and /t/, /d/ and /m/ consonants were affected more in Hawley's retainer, which took approximately 6 months to return to normal frequencies.

Jia Wan et al⁷ mentioned that sounds such as /i/, /f/, /h/, /s/, and /r/ showed severe impairments in speech while wearing Hawley's retainer by acoustic analysis; while our study showed significant changes in frequencies of /i/, /t/, /d/ and /m/ sounds.

It has been reported that Invisalign® therapy can offer aesthetically demanding patients an alternative to the lingual orthodontic treatment. However, Nedwed et al⁸ reported that 52 per cent of patients with Invisalign® experienced slight speech impairments. To the best of our knowledge, there has not been any related study conducting an objective evaluation of speech function caused by Invisalign® therapy, which merits further related studies. As we are progressing into an era of aligners, this study of the effect on speech by vacuum forms retainers will indicate the areas of speech likely to be affected by aligners also.

There are some factors other than speech which affect the choice of retainer. Barlin et al⁹ concluded that 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's. Therefore, when deciding on the type of retainer other factors such as cost may play a significant role.

Haydar et al¹⁰, who used horse shoe retainer, found that significant distortions were observed on the first day with the /t/ and /d/ consonant sounds. They also observed that the /s/ and /z/ consonant sounds appeared to be slightly distorted without retainers, so wearing retainers did not seem to cause any apparent distortions. However, in our study, the inclusion criteria were no articulation errors before wearing retainers; /s/ consonant sounds was found to be distorted in VCFR group after retainer wear and till approximately 5 months.

To reduce the influence of impairment in speech as much as possible, two measures ought to be taken: (1) to encourage retainer-wearing patients to practice distortion sounds, and (2) to alter the structure of the retainer in order to reduce its influence on speech.¹¹

V. Conclusion

From the results of the present study, it was observed that:

(1) Patients experience articulation problems when wearing both Hawley's and vacuum formed retainers but these problems gradually decreased with time. After 3 weeks of appliance wear, disarticulation problems either disappear completely or decrease for /a/, /e/, /n/, /s/, /z/ and /g/ to a level that does not impair the clarity of Speech with both retainers.

(2) Sounds such as /i/, /u/, /t/, and /d/ for the Hawley's retainer (HR) group and /i/, /u/, /t/, /d/, /m/ and /h/ for vacuum formed retainer (VFR) group showed significant alteration. Distortion is significantly observed till 6months for /t/, /d/, and /m/ sounds, while 3-4 months for /i/ and /u/ sounds.

(3) A comparison of the HR group with the VFR group revealed that the changes in articulation were more obvious in the Hawley retainer group.

Therefore, we concluded that within a limit, retainers may disturb speech and patients should be informed of the influence on speech caused by orthodontic retainers before their placement and should be encouraged to adapt to these changes. However, this adaptation period can last for 1 week or for as long as 3 months.

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