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Efficacy of Different Retention Types Post-Orthodontic Treatment

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Efficacy of Different Retention Types Post-Orthodontic Treatment

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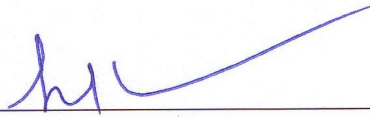
Master of Dental Science Thesis

Efficacy of Different Retention Types Post-Orthodontic Treatment

Presented by

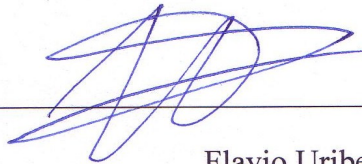
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Table of Contents

<u>Title</u>	<u>Page</u>
Title Page	i
Approval Page	ii
Table of Contents	iii
Abstract	iv
Chapter I – Introduction	1
Background	1
Review of Literature	4
Rationale	11
Hypotheses	13
Specific Aims	13
Chapter II – Methods and Materials	14
Chapter III – Results	18
Chapter IV – Discussion	26
Chapter V – Conclusions	32
Chapter VI – Figures	33
Literature Cited	36

Abstract

Introduction: Despite major advances in orthodontic tooth movement, orthodontic retention still remains a major problem. It has been estimated that only 10% of the population who have received orthodontics are still in acceptable occlusion as judged by orthodontists 20 years after retention. (Little, Riedel et al. 1988) In addition, very little is known about patient's perception in relation to orthodontic relapse. Therefore, the goal of this study was to evaluate the efficacy of 3 different types of retainers (Hawley removable, Essix removable and Fixed) of the mandibular and maxillary anterior sextant and to assess patient perception of crowding. **Materials and Methods:** A retrospective clinical evaluation of 80 patients treated at the University of Connecticut Health Center. These 80 patients were selected 1-2 years into retention based on complete records and consent to participate. Emodels (digital models) taken of the upper and lower arches were assessed pre- and post-orthodontically, and during retention for alignment of the anterior sextant using Little's *Irregularity Index*. The amount of Irregularity was compared for 3 retention groups (Hawley, Essix and Fixed). Relapse was also subjectively measured in the form of a questionnaire which was administered to each patient, documenting one's perception of their crowding and the amount of time the retainer was worn. **Results:** We found a significant increase in the *Irregularity Index* of the mandibular incisors during retention in patients wearing Hawley retainers compared to the patients that had Fixed retainers. In addition, patients wearing mandibular Hawley

retainers perceived their crowding significantly more than patients with Fixed retainers. Only half the patients with overall crowding in the maxillary and mandibular arch, noticed the crowding. **Conclusions:** Hawley retainers allow for more mandibular incisor movement than Fixed retainers. In addition, the finding that only half the patients with overall crowding actually notice the crowding, may suggest that the Hawley retainer patients may perceive more crowding due to factors unrelated to actual crowding.

Introduction

Background

DENTAL ANATOMY

The periodontium consists of four specialized tissues that surround the teeth and act as supportive structures. It consists of gingiva, alveolar bone, periodontal ligament and cementum. The alveolar bone is compact bone that surrounds the teeth, while cementum is hard tissue that surrounds the root surface of teeth. Sharpey's fibers insert into both of these structures, attaching the periodontal ligament (PDL) to cementum and alveolar bone. Typically, the PDL space is 0.5mm thick and contains a network of capillaries, nerves, fibroblasts and ground substance consisting of connective tissue polysaccharides, salts and water. (Brand 2003)

Majority of the fiber bundles found in the PDL start from the cementum and run coronally in a direction that is oblique to the bone. This arrangement acts as a shock absorber, which allows teeth to withstand the forces that occur in normal function. Masticatory forces are counteracted by the underlying PDL fibers, cells, interstitial fluid and alveolar bone, which flex to dissipate this stress. (Carranza 1996) The amount of force required to generate tooth movement, however, is greater.

BIOLOGY OF ORTHODONTIC RELAPSE

Orthodontics involves the application of force which generates a cellular response resulting in tooth movement. This force generates areas of compression and tension

within the periodontium, allowing tooth movement when its limit has been reached. Once teeth have been moved, the supporting periodontium needs to remodel to maintain the tooth in its new position. Relapse of these teeth is due to the supragingival fibers, specifically transseptal fibers. Oxytalan fibers have been found in the periodontium in addition to collagen fibers in areas of stress, which indicates that the body produces them during separation and destruction of tissues. These are thought to be responsible for the tensile force pulling teeth to their original location. (Parker 1972) Surgical transection of free gingival fibers has been shown in some studies to decrease relapse of teeth, possibly due to the removal of this tensile force. (Boese 1969; Brain 1969) Though, Edwards found circumferential supracrestal fiberotomy more effective in preventing pure rotational relapse than in reducing labiolingual relapse over the long term and it being more successful in the maxillary anterior sextant than the mandibular. (Edwards 1988) More recently, however, other studies have found the principal fiber of the PDL mediating relapse of teeth. In fact, these PDL fibers consist of collagen fibers and lacked oxytalan fibers altogether. (Yoshida, Sasaki et al. 1999)

ORTHODONTIC RETENTION

Orthodontic retention is the maintenance of teeth in the ideal position after active orthodontic treatment. For many years, orthodontists did not agree on the need for retention. In the 1800s, it was believed that the “occlusion of teeth” was the “most potent factor in determining the stability in a new position.” (Kingsley 1880) Later in 1925, Lundstrom suggested that the apical base was the most important factor in maintaining retention. (Lundstrom 1925) McCauley believed that transverse widths of canines and

molars played a major role in maintaining retention. (McCauley 1944) Eventually the Tweed philosophy arose, where the inclination of incisors were considered more retentive if they were upright. (Tweed 1944) In order to achieve this, extraction of premolars were promoted for stability. More recently, it was established that active retention needs to be lifelong, because regardless of years of no relapse, there is still a tendency for relapse to occur. (Little, Riedel et al. 1988)

Retention can be achieved by various appliances. The Hawley retainer is one of the most frequently used retentive removable appliances after a patient has undergone orthodontic treatment. (Hawley 1919) It consists of a palatal portion made of acrylic and a labial bow of 0.020 to 0.036 inch stainless steel wire. The Essix retainer is also removable but is typically made from 0.030 inch plastic, which completely covers all surfaces of the teeth. The Fixed retainer is a permanent retainer, which can be done two ways. One way is to use a rigid 0.025 stainless steel wire and bond it only to the canines (canine-and-canine), which allows easier maintenance of oral hygiene in the incisor region. The second way is canine-to-canine Fixed retention, which entails using an 0.0175 inch wire bonded to all the teeth in the anterior sextant. If bonding all 6 anterior teeth, the wire used for Fixed retention should be flexible enough to allow physiologic tooth movement, yet maintain the teeth in the intended position. Fixed retention has its advantages since it does not rely on patient compliance, though it can make hygiene more difficult.

Success of treatment is measured by the orthodontist achieving the intended objectives, maintaining the teeth during retention and satisfying the patient. Patient perception plays a major role in determining clinical success. Clinical experience

suggests that most patients have limited understanding for occlusion and posterior dentition, but what they do recognize is anterior crowding. In fact, the majority of patients that want re-treatment, want it due to crowding that occurred during retention.

MEASURING RELAPSE

Study casts have been used for decades to measure post-treatment and/or post-retention alignment. Arch perimeter to tooth size discrepancy was commonly used as a measure of incisor crowding until Little proposed the *Irregularity Index*. (Little 1975) It is a measurement technique defined by the summed displacement of adjacent anatomic contact points of the mandibular anterior teeth. It has also been used in the maxillary anterior sextant. Though it does not always give a “valid estimate of space deficit,” it does “correlate highly with the amount of anterior crowding” (BeGole and Sadowsky 1999).

Review of Literature

REMOVABLE RETENTION

Many investigations have compared various removable retainers and their effects on occlusal settling. What they found was that retainers which allow occlusal contacts during wear (i.e Hawley retainers), show better settling compared to those which do not (i.e. Essix retainers). However, controversy still exists in whether Essix retainers are more effective in maintaining incisor position during retention compared to its Hawley

counterpart. Some studies have shown that Essix retainers are better than Hawley retainers, while others have shown no statistical difference between the two.

REMOVABLE RETENTION AND OCCLUSION

In 2007, **Basciftci et al.** compared a total of 60 patients divided into 3 equal groups consisting of those with **Hawley retainers, Jensen plates and a control group** with normal occlusion. (Basciftci, Uysal et al. 2007) In the orthodontically treated group, **occlusal contact differences were measured** from time of debonding to approximately 1 year into retention whereas the control group underwent the same measurement from occlusal records taken approximately 1 year apart. Results revealed that **after the 1 year** mark, **no statistically significant occlusal contact differences** were observed in all 3 groups. Later in 2009, **Horton et al.** evaluated the short-term changes in posterior occlusion in those utilizing a **Hawley retainer versus** those with a **perfector/spring retainer**. (Horton, Buschang et al. 2009) In total, 50 patients who had completed orthodontic treatment were randomly divided into 2 retention groups, 28 were allocated to the Hawley group whereas 22 were allocated to the perfector/spring aligner group. **Occlusal contact differences were measured** objectively from time of initial delivery of retainer to approximately 2 months thereafter and also subjectively by using a 7-item questionnaire which assessed the patient's perception of occlusion. The study revealed that **occlusal contacts substantially increased in both types of retainers, however, patients wearing the perfector/spring aligner reported greater improvement** in how their posterior teeth occluded and less discomfort when occluding.

There have been studies also comparing the effectiveness of **Hawley retainers to Essix-type retainers**. Essix retainers, compared to Hawley retainers, offer some clear advantages to the patient including being less costly, less conspicuous and easier to wear. However, Essix retainers impede the occlusal surfaces from contacting and thus can interfere in settling. **Sauget et al.** in 1997 investigated the role of **Hawley retainers versus clear overlay retainers on occlusal contacts**, in a prospective non-randomized study. (Sauget, Covell et al. 1997) Thirty orthodontic patients were utilized, each of which had their occlusal contacts quantified at the debanding stage, retainer insertion stage and 3 months into retention. The results revealed that **those wearing the Hawley retainer showed a greater increase in occlusal contacts** leading to the conclusion that Hawley retainers allow for relative vertical movement of teeth (settling) whereas, the clear overlay retainer maintains tooth position from the debonding stage.

REMOVABLE RETENTION AND INCISOR IRREGULARITY

In 1998, **Lindauer et al.** conducted a prospective non-randomized clinical trial comparing Hawley retainers and Essix retainers in the first 6 months of retention. (Lindauer and Shoff 1998) The difference in their study was that they were **specifically looking at incisor changes**. The specific **Essix retainer used extended only from canine to canine in the maxillary and mandibular arch**. Of the 40 patients, 21 utilized the **Hawley** retainer and 19 utilized the Essix retainer. It was found that **no significant differences existed with respect to incisor irregularity**, overbite and overjet between the 2 types of retainers. Much later in 2007, **Rowland et al.** implemented a prospective single-center randomized controlled trial to investigate the **effectiveness of Hawley and**

vacuum-formed (aka. Essix) retainers. (Rowland, Hichens et al. 2007) A total of 396 patients were randomly given either a Hawley retainer or a vacuum-formed retainer, though 155 in each group were eventually analyzed. Dental casts of the maxilla and mandible at the debonding stage and 6 months into retention were assessed for rotations, overjet, overbite, inter-molar widths, intercanine widths and Irregularity Index of the anterior sextant. There was a significantly **greater change in the Irregularity Index for the Hawley retainer compared to the vacuum-formed retainer.** They concluded that vacuum-formed retainers are more effective in stabilizing the maxillary and mandibular anterior segments.

FIXED RETENTION

Various studies have shown that Fixed retention bonded only to canines have relapse, while others have shown that even though relapse exists, it is not significant or clinically relevant. Other studies have assessed Fixed retention including incisors and have shown both: better stability and more movement due to its technique sensitivity. Only one study compared Fixed retention with Removable retention and their focus was on tooth wear, not movement of the incisors. The Cochrane Collaboration published a report in 2009 indicating that more research is required in comparing different types of retainers. (Littlewood, Millett et al. 2006) Further, most studies have focused on mandibular anterior alignment, while the maxillary anterior alignment has been studied to a much lesser degree.

FIXED RETENTION ALONE

In 2002, **Störmann et al.** (Störmann and Ulrike 2002) in a prospective randomized study, compared **2 types of Fixed mandibular retainers** with respect to detachment rate, relapse, periodontal problems, oral hygiene and subjective patient discomfort. In total, 103 patients had either canine-to-canine (bonded to 6 teeth) or canine-and-canine (bonded to 2 teeth). Using **Little's irregularity index** to measure relapse over a period of 24 months, it was **found that canine-to-canine retainers had a greater degree of stability whereas the canine-and-canine retainers** were associated with **frequent relapse of the incisors not bonded.**

In 2007, **Katsaros et al.** (Katsaros, Livas et al. 2007) examined the unexpected post-treatment changes in the mandibular anterior region associated with the **flexible spiral wire retainer bonded to 6 teeth.** For a 3 year period, patients were screened for these unexpected changes during their regular follow-up appointments. In total, 21 patients were found to have complications, of which 18 patients had a torque difference between 2 adjacent mandibular incisors and 2 patients had increased buccal inclination of a mandibular canine. Although the authors never stated the total number of patients screened, they estimated approximately **5% of patients with this particular type of retainer experienced either of these complications.**

In 2001, **Watted et al.** (Watted, Wieber et al. 2001) investigated the effect of **mandibular canine-to-canine lingual retainers bonded to 2 or to 6 teeth** on incisor mobility. With a total of 60 participants, divided into 3 equal groups (2 groups with mandibular bonded retainers and one control group with removable retainers), the study yielded **tooth mobility decreased with the number of teeth bonded to the retainer.**

In 2006, **Naraghi et al.** (Naraghi, Andren et al. 2006) retrospectively looked at 45 patients to examine the amount of relapse of the **maxillary anterior teeth** when using a **bonded retainer**. Each patient contributed casts before treatment, at the end of treatment, and 1 year post-treatment from which the irregularity index and the rotations of the front teeth from the raphe line were calculated. The results revealed a significant decrease in the **irregularity index** from before to end of treatment and a significant angle for correction during the same time period. From the end of treatment to 1 year post-treatment, **minor or no relapse was noted**.

In 2008, **Booth et al.** (Booth, Edelman et al. 2008) set out to evaluate the effectiveness and gingival health effects of **Fixed retainers bonded to canines** and followed-up 20 or more years after placement. This was another retrospective study where 45 of 60 patients still had their retainers in place. Of the 45 patients, 1 had an irregularity index score > 2mm whereas of the 15 patients who had their retainers removed, 13 had scores > 3mm and 5 had scores > 4mm. These results convey that **Fixed retention (bonded to canines) is associated with maintenance of alignment of mandibular anterior teeth** if 3mm is acceptable for relapse.

In 2008, **Renkema et al.** (Renkema, Al-Assad et al. 2008) published a large retrospective study that explored the effectiveness of lingual retainers **bonded to canines** in preventing relapse of mandibular incisors. Using the dental casts of 235 patients with canine-and-canine mandibular lingual retainers, the corresponding Irregularity Index was measured before treatment, after treatment, 2 years after treatment and 5 years after treatment. It was found that the irregularity index decreased significantly from before the start of treatment to the end of treatment and thereafter. In 60% of subjects, the

irregularity index was stable during the post-treatment period and **in 40%, the irregularity index exhibited a slight increase (0.4mm) during the same post-treatment period.**

FIXED RETENTION COMPARED TO REMOVABLE RETENTION

In 2009, **Kuijpers** et al. conducted a retrospective study involving 222 subjects, all of which were followed for 5 years post-treatment. (Kuijpers, Kiliaridis et al. 2009) In the maxilla, a **bonded retainer on all 6 teeth or a removable retainer** was used whereas in the mandible, a bonded lingual retainer either to all 6 teeth or just the canines was used. Along with the degree of wear of the upper and lower incisors/canines, the upper and lower intercanine width and the lower anterior alignment (*Irregularity Index*) were measured. It was found that the Irregularity Index decreased significantly from before treatment to the end of treatment and then increased significantly when measured 5 years post-treatment. With respect to the intercanine distance, there was a significant increase in both the maxilla and mandible. **Anterior tooth wear increased through all phases and was more significant for those with maxillary removable retainers. Their study did not specifically assess whether one method of retention showed less incisor irregularity.**

PATIENT PERCEPTION

It is important to take the patient's perception into consideration when dealing with a field that is driven by esthetics. It makes sense that **Horton et al.** evaluated the patients' perception of alignment with **Hawley retainer versus perfector/spring**

retainer. (Horton, Buschang et al. 2009) They used a 7–item questionnaire that assessed the patient’s perception of occlusion. Their questions focused on posterior occlusion and if the patient felt that their “back teeth fit together.” They found that although both the Hawley group and the perfector/spring group both had increases in posterior contacts during retention, the perfector/spring group reported significantly greater improvement.

In 2010, Mollov et al. published a study that looked solely at patient perception. (Mollov, Lindauer et al. 2010) They conducted a survey that was distributed to previous orthodontic patients, first year undergraduate college students, first year dental students and retention patients in their orthodontic clinic. Four hundred twenty eight participants of the 555 indicated that they had previous orthodontic treatment. There was a strong relationship between the perception of tooth stability and current satisfaction. After analysis of their extensive questionnaire, they concluded that patients’ satisfaction with orthodontic results is related to their own responsibility for retention. However, they did not relate that information back to dental model analysis of actual crowding.

Rationale

Reitan in 1967 showed that the fibers around the teeth take on average 232 days to remodel to the new position. (Reitan 1967) Decades later, knowledge still remains to be gained with regards to the efficacy of different retention methods and the resulting alignment in the mandibular and maxillary anterior sextant. Littlewood, in The Cochrane Collaboration, stated himself that “research is required in the following areas: to compare different types of retainers (Fixed and Removable).” (Littlewood, Millett et al. 2006)

Furthermore, success of orthodontic treatment is ultimately the patient's perception of success. What orthodontic clinicians may think is successful in terms of occlusion, reaching treatment objectives, etc., means nothing to the patient who is concerned with anterior crowding. The objective of this study was to assess the effectiveness of different retainer types as well as consider patient's perception of crowding, so that a better understanding can be obtained.

Hypothesis

Hypothesis 1: Mandibular anterior alignment will be better retained with Fixed or Essix retainers compared to Hawley retainers.

Hypothesis 2: Patients with crowding at 1-2 years into retention, will notice the crowding.

Null Hypothesis 1: Mandibular anterior alignment will not change regardless of the type of retainer worn.

Null Hypothesis 2: Patients with crowding at 1-2 years into retention will not notice the crowding.

Specific Aims

Aims/Objective/Prediction

1. To evaluate efficacy of different retention methods in maintaining mandibular anterior alignment during retention by using Little's *Irregularity Index* to measure changes post-treatment and 1-2 years later into retention.
2. To see if patients notice small amounts of crowding during retention.

Materials and Methods

In order to test these hypotheses, a retrospective clinical study involving orthodontic patients who completed treatment and were fitted with retainers, was conducted. Before commencing, an Institutional Review Board application was submitted and approved at the University of Connecticut. Patients from the Orthodontic Clinic at the University of Connecticut that were in retention between 1-2 years were called in to be evaluated. Records of over 600 patients were screened to select the sample using the following **inclusion criteria**:

- A record containing electronic dental models (Emodels) pre-treatment (T1) and post-treatment (T2).
- Patients with a full complement of dentition with the exception of third molars or teeth extracted for orthodontic reasons.

Exclusion criteria:

- Patients with multiple missing teeth
- Patients treated for Phase I
- Patients with evidence of periodontal disease
- Patients who received circumferential fiberotomies
- Fixed prosthesis in the anterior sextant of the maxillary and/or mandibular arch

Patients were contacted for a recall visit to evaluate retainer wear, perception of tooth stability, and magnitude of incisor *Irregularity*. In the recall visit, alginate impressions were taken with a wax bite registration for the fabrication of follow up digital models (T3). (See Figure 1) Anterior alignment of the maxillary and mandibular arches were

assessed using Little's *Irregularity Index* with the Emodels for T1, T2 and T3 time periods. (See Figure 2) The amount of *Irregularity* at T2 was subtracted from T3 Emodels, to give the amount of Irregularity change during the time when the patient was in the retention phase. Data was collected on the type of retainer the patient had been wearing: Fixed bonded (3-3) or removable (Essix or Hawley). Measurements were made twice by two examiners on two separate occasions (two weeks apart) to evaluate reliability. To assess the patients' amount of retainer wear and perception of crowding, the patients were asked to complete the following questionnaire:

Questionnaire

1. Did you get clear instructions to wear the retainer?

YES NO

2. Do you think your teeth have moved?

YES NO

3. Please quantify how much you wore your retainer in the **last 6 months** by circling one of the following:

Days worn weekly: 7 days 6 days 5 days 4 days 3 days 2 days 1 day 0 day

Amount of time worn daily: ~ 24 hrs (except when eating or brushing)

22 hrs 20 hrs 15 hrs 12hrs 10hrs 7 hrs 5 hrs 3 hrs 1 hr 0 hr

Scientific Background

In 1975, Little proposed a quantitative method of assessing mandibular anterior irregularity, which was different from the traditional arch perimeter tooth size discrepancy method – which had its own inherent problems. The Irregularity Index, which has since been used by many studies, was developed to measure the summed displacement of adjacent anatomic contact points of the mandibular anterior teeth in a reproducible way. (Little 1975) The technique involves measurement directly from the mandibular cast with a caliper (calibrated to at least tenths of a millimeter) held parallel to the occlusal plane. The linear displacement of the adjacent anatomic contact points of the mandibular incisors is determined, the sum of the five measurements representing the Irregularity Index value of the case. In our study, this was done using digital Emodels or calibrated digital models.

Results

All the active retention charts at the University of Connecticut Health Center orthodontic department were screened. Over 600 records were consulted for eligibility with regards to inclusion and exclusion criteria. Of those that fit the criteria and did not have their retainers replaced over the course of retention, only 80 patients were able to be reached and consented to participation in this study, due to lack of updated contact information. Of the 80 patients that participated in the study, both maxillary and mandibular arches may not have qualified. Thus, the final number of arches was not 160 but rather 108. It was extremely difficult to obtain enough patients in the Essix removable group because often they were also given Hawley retainers as back up retainers, thus they did not qualify for the study.

COMPARISON OF IRREGULARITY INDEX AND TYPE OF RETAINER

Measurements were done on Emodels for T2 (debond) and T3 (1-2 years into retention). In the mandibular arch (Table 1), there was 0.89mm difference in the Hawley group and 0.27mm in the fixed group. This 0.62mm difference was found to be significant ($p < .037$) using a Mann-Whitney U test (non-parametric test). There were no significant results when comparing all three retainer types (Hawley vs. Fixed vs. Essix). When looking at the maxillary results (Table 2), the difference in mean crowding in the maxillary anterior sextant between T2 and T3 was not significant for Hawley vs. Essix patients.

Initial pre-treatment models (T1) were measured and it was found that no patients had less than 3mm *Irregularity* in the maxillary anterior sextant, while 27 patients had

more than 3mm. In the mandibular arch, 8 patients had less than 3mm *Irregularity* and 27 patients had greater than 3mm. Unfortunately, the rest of the pre-treatment models could not be measured due to canines not being fully erupted into the arch (Figure 3).

Table 1: Means and standard deviations for mandibular model *Irregularity* at time 2 (T2) and time 3 (T3) by retainer type, with amount of days/hours of retainer wear.

Variable	Hawley			Fixed			Essix			Total		
	<u>N</u>	<u>Mean</u>	<u>SD</u>	<u>N</u>	<u>Mean</u>	<u>SD</u>	<u>N</u>	<u>Mean</u>	<u>SD</u>	<u>N</u>	<u>Mean</u>	<u>SD</u>
Mandibular T2	20	0.54	0.58	19	0.24	0.47	8	0.30	0.37	47	0.38	0.52
T3	20	1.48	1.66	19	0.58	0.94	8	0.86	0.56	47	1.01	1.30
Amt Days	21	4.10	2.45	24			9	5.67	1.22	55	4.85	2.19
Amt Hrs	21	8.57	5.18	24			9	7.89	1.83	55	9.73	6.19

Note: Totals are means and standard deviations across treatment conditions;
SD = Standard deviation; N = sample size.

Table 2: Means and standard deviations for maxillary model *Irregularity* at time 2 (T2) and time 3 (T3) by retainer type, with amount of days/hours of retainer wear.

Variable	Hawley			Essix			Total		
	<u>N</u>	<u>Mean</u>	<u>SD</u>	<u>N</u>	<u>Mean</u>	<u>SD</u>	<u>N</u>	<u>Mean</u>	<u>SD</u>
Maxillary T2	52	0.63	0.93	9	1.14	0.85	61	0.71	0.93
T3	52	1.69	1.32	9	1.66	1.09	61	1.69	1.28
Amt Days	58	4.38	2.32	10	5.70	1.34	68	4.57	2.24
Amt Hrs	58	8.34	5.15	10	8.10	1.85	68	8.31	4.80

Note: Totals are means and standard deviations across treatment conditions;
SD = Standard deviation; N = sample size.

TYPE OF RETAINER AND PERCEPTION OF CROWDING

In terms of perceived crowding, mandibular perceived crowding showed significantly less perceived crowding in the Fixed group (21%) compared to the Hawley patients (57%) at $p < .042$ (Table 3). Maxillary perceived crowding that was not significant when patients were divided into different groups based on retainer type (Table 4).

Table 3: Perceived mandibular crowding by retainer type.

	Hawley		Fixed		Essix	
<u>Perceived</u> <u>Mandibular</u> <u>Crowding</u>	<u>N</u>	<u>%</u>	<u>N</u>	<u>%</u>	<u>N</u>	<u>%</u>
No	9	43	19	79	5	56
Yes	12	57	5	21	4	44
Total	21	100	24	100	9	100

Note: Cell entries reflect count and percent of total within each treatment condition.

Table 4: Perceived maxillary crowding by retainer type.

	Hawley		Essix	
<u>Perceived</u> <u>Maxillary</u> <u>Crowding</u>	<u>N</u>	<u>%</u>	<u>N</u>	<u>%</u>
No	29	50	4	40
Yes	29	50	6	60
Total	58	100	10	100

Note: Cell entries reflect count and percent of total within each treatment condition.

CROWDING AND PERCEPTION

In terms of overall crowding, regardless of the retainer type or arch, 59 patients had crowding at T3. Out of these patients, 28 patients didn't notice any crowding, while 31 patients did.

Table 5: Perceived crowding in patients with actual crowding (aka. Positive *Irregularity Index*)

	<u>N</u>
NO	28
YES	31
Total	59

The patients were then segmented differently (at T3) to see if the amount of crowding changed their perception. (Tables 6-11) What was found was regardless of the specific amount we analyzed, about half the patients noticed the crowding, while half did not.

Table 6: Perceived crowding at T3 in the mandibular arch in patients with *Irregularity Index* of 0.1mm to < 2mm

	<u>N</u>
NO	15
YES	10
Total	25

Table 7: Perceived crowding at T3 in the mandibular arch in patients with *Irregularity Index* of $\geq 2\text{mm}$

	<u>N</u>
NO	3
YES	4
Total	7

Table 8: Perceived crowding at T3 in the maxillary arch in patients with *Irregularity Index* of 0.1mm to $< 2\text{mm}$

	<u>N</u>
NO	14
YES	15
Total	29

Table 9: Perceived crowding at T3 in the maxillary arch in patients with *Irregularity Index* of $\geq 2\text{mm}$

	<u>N</u>
NO	7
YES	13
Total	20

Table 10: Perceived crowding at T3 in the mandibular arch in patients with *Irregularity Index* difference (T3-T2) of 0.1mm to < 0.5mm

	<u>N</u>
NO	2
YES	1
Total	3

Table 11: Perceived crowding at T3 in the mandibular arch in patients with *Irregularity Index* difference (T3-T2) of ≥ 0.5 mm

	<u>N</u>
NO	12
YES	9
Total	21

Reliability Analysis

Reliability was established using the intra-class correlation coefficient (ICC). The ICC indicates the ratio of systematic variability in measurements relative to unsystematic variability (i.e., error), and yields a value between 0 (no reliability) and 1.0 (100% reliability). Two sets of reliability analyses were conducted. The first analysis assessed the reliability for the same rater on measurements taken at two different points in time (2 weeks apart). Within-rater reliabilities for raters 1 and 2 are shown below in Table 1.

Table 1: *Within-rater reliability for two raters.*

Variable	Rater	Debond	During Retention
Maxillary Models	1	0.99	0.99
	2	0.97	0.96
Mandibular Models	1	1.00	1.00
	2	0.95	0.99

Note: Cell entries are intra-class correlation coefficients assessing measurement reliability at debond and during retention for each rater, measured at two points in time (2 weeks apart).

Overall, ICCs ranged from .95 to 1.00, indicating excellent within-rater reliability. Both raters were highly consistent in their sets of measurements both at debond and during retention.

The second analysis assessed the reliability of the two independent raters on measurements taken at two points in time. The results are presented below in Table 2.

Table 2: *Between-rater reliability.*

Variable	Debond	During Retention
Maxillary Models	0.74	0.72
Mandibular Models	0.66	0.87

Note: Cell entries are intra-class correlation coefficients assessing measurement reliability at debond and during retention between two raters.

For the 2 independent raters, ICCs ranged from .66 to .87. In general, ICCs between .60 and .80 are considered acceptable, while those greater than .90 are deemed to be exceptional. (Nunnally 1994) ICC's were assessed statistically and were all found to be highly significant (all p 's < .001).

Discussion

Studies have found conflicting results when comparing Essix retainers to Hawley retainers in maintaining incisor position during retention. Some studies have shown that Essix retainers are better than Hawley retainers, while others have shown no statistical difference between the two. (Lindauer and Shoff 1998; Rowland, Hichens et al. 2007) Studies have lacked the comparison of all 3 retainer types: Essix, Hawley and Fixed. (Littlewood, Millett et al. 2006) In addition, studies considering patient perception during retention are limited.

In 1998, Lindauer et al. conducted a prospective non-randomized clinical trial comparing Hawley and Essix retainers in the first 6 months of retention. (Lindauer and Shoff 1998) Their study specifically looked at incisor changes, which is what we are interested in. However, their Essix retainer only extended from canine to canine in the maxillary and mandibular arch, which is not always the type of Essix used by orthodontists. Many clinicians use Essix retainers encompassing the entire dental arch. In their study, they had a total of 40 patients, 21 Hawley patients and 19 Essix patients. It was found that no significant differences existed with respect to incisor irregularity between the 2 types of retainers. Rowland et al. felt that Lindauer et al. didn't have enough patients, so they constructed a prospective single-center randomized controlled trial to investigate the effectiveness of Hawley and full coverage Essix retainers. (Rowland, Hichens et al. 2007) A total of 396 patients were randomly given either a Hawley retainer or Essix retainer, though 155 in each group were eventually analyzed. Dental casts of the maxilla and mandible at the debonding stage and 6 months into retention were assessed for the *Irregularity Index* of the anterior sextant. They found a

significantly greater change in the *Irregularity Index* for the Hawley retainer group compared to the Essix retainer group. They did not relate this back to patient perception or look at patients with Fixed retainers.

In terms of studies that have looked at Fixed retainers bonded to incisors and canines in the mandibular anterior sextant, studies that compare Fixed retainers to removable retainers are scarce and most fail to consider patient perception. Störmann et al. conducted a prospective randomized study, which compared 2 types of Fixed mandibular retainers in 103 patients: canine-to-canine (bonded to 6 teeth) or canine-and-canine (bonded to 2 teeth). They used Little's *Irregularity Index* to measure relapse over a period of 24 months and found that canine-to-canine retainers had a greater degree of stability whereas the canine-and-canine retainers were associated with frequent relapse of the incisors not bonded. (Störmann and Ulrike 2002) Katsaros et al. examined post-treatment changes in the mandibular anterior sextant associated with the flexible spiral wire retainer bonded to incisors and canines. For a 3 year period, patients were screened for these unexpected changes during their regular follow-up appointments. In total, 21 patients were found to have complications, of which 18 patients had a torque difference between 2 adjacent mandibular incisors and 2 patients had increased buccal inclination of a mandibular canine. Although the authors never stated the total number of patients screened, they estimated approximately 5% of patients with this particular type of retainer experienced either of these complications. (Katsaros, Livas et al. 2007) Watted et al. investigated the effect of mandibular canine-to-canine lingual retainers bonded to 2 or to 6 teeth on incisor mobility. With a total of 60 participants, divided into 3 equal groups: canine-to-canine Fixed retainer, canine-and-canine Fixed retainer and one

control group with removable retainers, the study showed that tooth mobility decreased with the number of teeth bonded to the retainer. They did not, however, specify which removable retainer was used for the control group and did not look at patient perception. (Watted, Wieber et al. 2001)

Few studies have taken patient perception during retention into account. Horton et al. evaluated the patients' perception of occlusion with Hawley retainer versus perfector/spring retainer. (Horton, Buschang et al. 2009) They used a questionnaire that assessed the patient's perception of posterior occlusion, which did not consider incisor crowding. They used this information to then relate it to dental models, which were used to measure the amount of contact between the two arches. What they found was that although both the Hawley group and the perfector/spring group had increases in posterior contacts during retention, the perfector/spring group reported significantly greater improvement. However, they did not measure anterior crowding and relate that back to patients' perception of crowding. Mollov et al. published a study that looked solely at patient perception during retention via a questionnaire. (Mollov, Lindauer et al. 2010) Four hundred twenty eight participants of the 555 indicated that they had previous orthodontic treatment. There was a strong relationship between the perception of tooth stability and current satisfaction. After analysis of their extensive questionnaire, they concluded that patients' satisfaction with orthodontic results is related to their own responsibility for retention. However, they did not relate that information back to dental model analysis of actual crowding. Booth et al. specifically addressed mandibular incisor alignment relapse with regard to canine-to-canine fixed retention, but made conclusions about patient perception of crowding that were not substantiated. (Booth, Edelman et al.

2008) They stated that most patients in their study had less than 2mm *Irregularity* during retention, which was acceptable to most patients. However, they did not specify how they measured patient satisfaction and there was no mention of any questionnaire.

In addressing the need for comparison of more retainer types and relating actual crowding to patient perception, a retrospective clinical evaluation of 80 patients treated at the University of Connecticut Health Center was performed. These 80 patients were selected 1-2 years into retention based on complete records and consent to participate. Emodels (digital models) taken of the upper and lower arches were assessed pre-orthodontics (T1) and post-orthodontics (T2), and during retention (T3) for alignment of the anterior sextant using Little's *Irregularity Index*. *Irregularity* at T3 was measured, but the difference from T3 to T2 was taken because *Irregularity* at the end of orthodontic treatment (T2) may not have been zero. When looking at the mean difference in *Irregularity* between T3 and T2, no significant findings were found for mandibular Hawley vs. Fixed vs. Essix groups. This may have been due to the Essix group not having a large enough sample size. However, when comparing the Hawley and Fixed group alone, the Hawley group was found to have 0.62mm more crowding than the Fixed group. This was found to be significant using a Mann-Whitney U test ($p < .037$). The same mandibular Hawley group was found to have more perceived crowding than the Fixed group ($p < .042$), which one could naturally think is because the Hawley group had more crowding and thus those were the patients that noticed it. However, the finding that only half the patients with overall maxillary and mandibular crowding actually noticed the crowding, suggests that the Hawley retainer patients may perceive more crowding due to factors unrelated to actual crowding. Segmenting the patient pool to account for

different amounts of crowding and still resulting in approximately half the patients noticing the crowding while half the patients did not, indicates that this may be true. Psychological factors related to removable retainers may be why those patients thought they had more crowding than patients with Fixed retainers in the mandibular arch.

In terms of the limitations of this study, the design was retrospective with no randomization or control group. This posed many challenges. It was extremely difficult to obtain enough patients in each group, especially the Essix group. Many patients that were given Essix retainers were often given backup Hawley retainers for no particular reason other than operator preference, thus these patients were automatically excluded from this study. In terms of the Fixed retainer group, the Fixed retainers were placed by many different graduate students in the orthodontic clinic, thus not accounting for varying techniques, different bonding agents and different skill levels when placing the Fixed retainer. Given the retrospective nature of the study, it was also difficult to monitor how much the patients actually wore their removable retainers. The questionnaire attempted to address this issue, but relied on patients self reporting the amount of wear. Another problem was that patients were not separated into different groups for their initial occlusion, thus we can't comment on how that may have affected their final occlusion or relapse. An attempt was made to go back to initial models to account for initial crowding, but many patients didn't have the canines fully erupted, thus measuring the *Irregularity* was impossible for several patients.

Reaching the patients was a big challenge. Most of the patients were Medicaid patients and their phone numbers were not up-to date in their charts. When certain patients were finally reached, they would book an appointment and not show up.

Occasionally, when they would come to the appointment, there were additional problems with their retainer that automatically excluded them from the study i.e. broken retainer or debonded Fixed retainer.

There are so many ways to refine a study of retention for the future. It would be best if it were prospective and randomized in nature, but having canines fully erupted in the arch so that pre-treatment measurements could be done for crowding, would be ideal. Also accounting for extraction of premolars, angulation of incisors, type of malocclusion, type of treatment rendered, duration of treatment, timing of treatment, and having a measuring device in the removable appliance for amount of wear, would be a great asset.

Conclusions

By knowing that differences exist between different types of retainers in maintaining anterior alignment, we can modify our retention protocols accordingly. A future study can use the information gathered here and apply it to a prospective randomized clinical trial. Furthermore, having an understanding of the patient's perspective in terms of crowding, helps us better treat our patients.

We conclude the following from this study:

1. Hawley retainers allow more relapse in terms of crowding than fixed retainers in mandibular anterior sextant.
2. Patients wearing mandibular Hawley retainers with more crowding compared to Fixed retainers, perceive this crowding more than patients with Fixed retainers.
3. Only half the patients with crowding in the maxillary or mandibular arch, notice the crowding during retention, which may suggest that the mandibular Hawley retainer patients may perceive more crowding due to factors unrelated to actual crowding.

Figures

Figure 1: Example of Emodel (digital model):

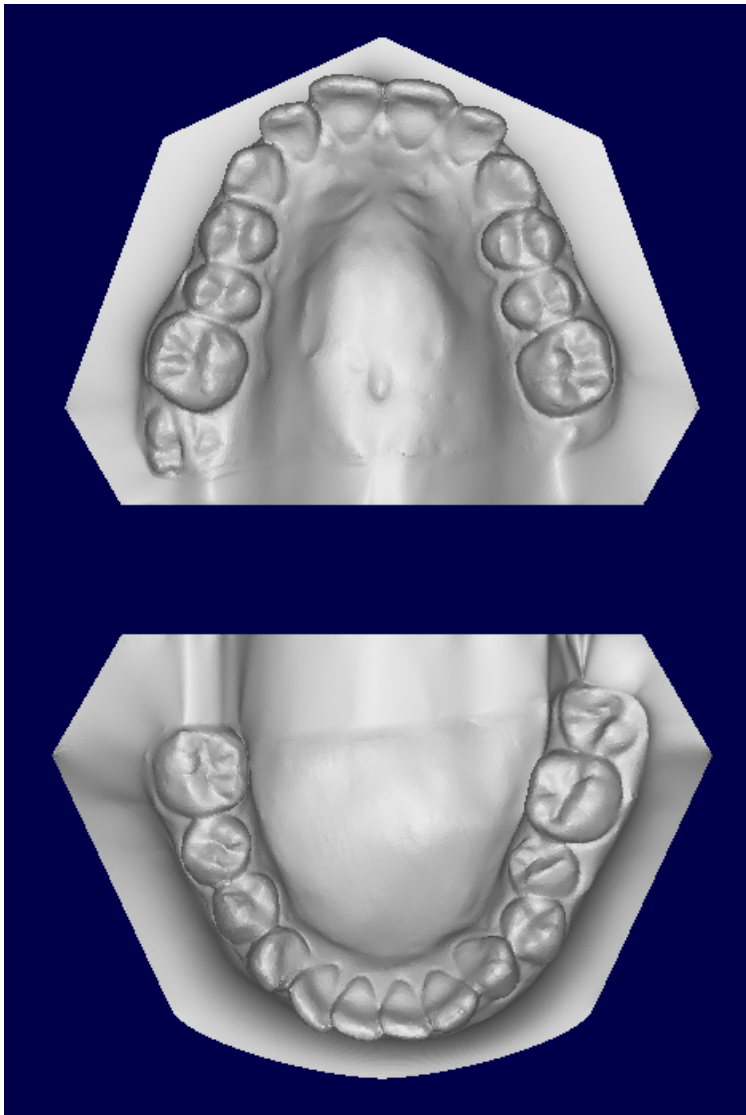


Figure 2: Example of measuring the *Irregularity Index* on Emodels:

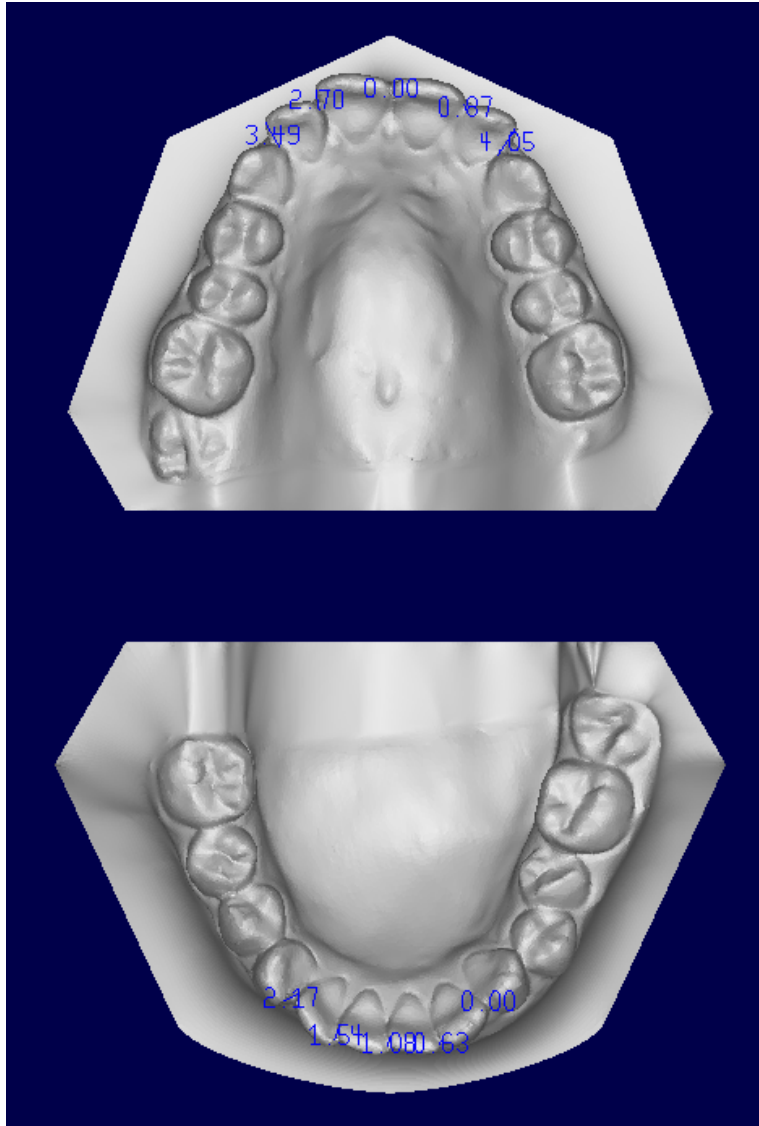
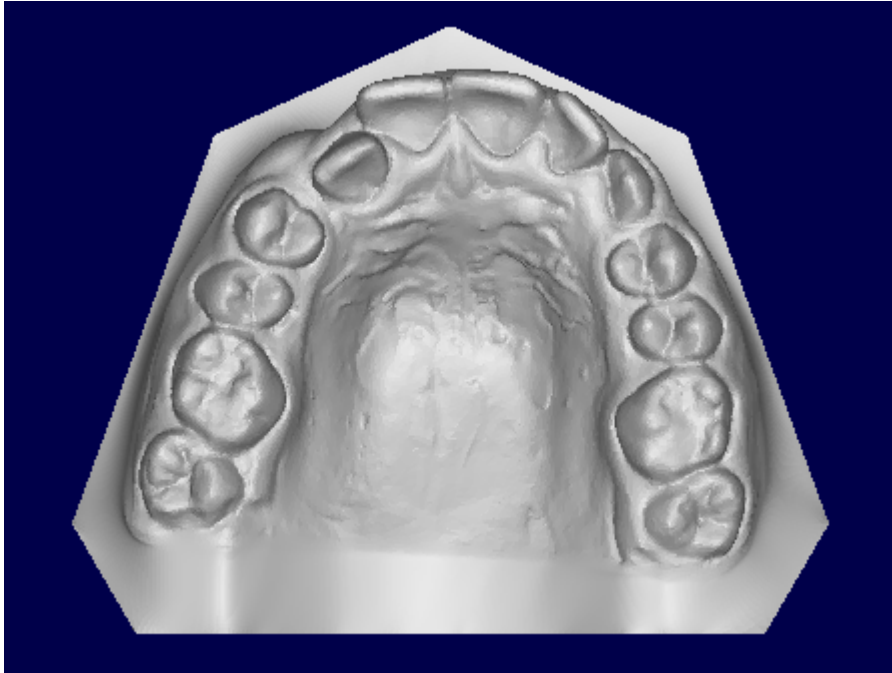


Figure 1: Example of Pre-treatment Model that could not be measured due to unerupted canines:



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