Comparison of Post-Treatment Occlusal Settling, Alignment, and Functional Occlusion Utilizing Hawley Versus Circumferential Maxillary Retainers.

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Table of Contents

Introduction

Orthodontists are universally aware of the necessity of retention devices in post-orthodontic treatment patients to preserve the stability of the newly aligned occlusion. Studies have shown that, without it, many cases tend to revert to the pre-treatment position. In 1920, Calvin Case stated, "But after all, what does this temporary pleasure and satisfaction to ourselves and our patients amount to, if we find in a few years that the very cases which create in us the greatest pride, are going back to their former malposition and disharmonies, in spite of everything we have been able to do with retaining appliances?" Case's words have as much significance to the profession today as they did almost 60 years ago [25]. Despite the demonstration of individual cases in which no apparent relapse has occurred post-treatment, the common use of retention appliances provide testimony to the frequency of relapse [29].

Since 1872, when Brown-Mason first recognized the need for retention, orthodontists have been pursuing optimal stability, hoping for post-retention settling, while trying to minimize the relapse of orthodontically treated cases by selecting the best retention appliance [26]. Retention is defined as the period of orthodontic treatment during which a passive appliance is used to maintain the post orthodontic correction of the

dental and skeletal structures. Therefore, retention appliances are used to counteract the tendency for the teeth to relapse and adopt the characteristics of the original malocclusion [25]. Joondeph and Reidel explain retention as the holding of teeth in ideal aesthetic and functional positions, while allowing the teeth to settle.

Post retention settling can therefore be described as the establishment of a desired position, the teeth settle into occlusion and thus become comfortably adapted to a new environment or situation.

Stability, on the other hand, is the condition of maintaining equilibrium. This refers to the quality or condition of being stable, the fixity of position in space, or the capacity for resistance to displacement.

Relapse is defined as falling back into or reverting to a former habit or state. Specifically, Horwitz and Hixon define relapse as " Changes in tooth position after orthodontic treatment." Reidel believed that the word "relapse" was too harsh a description of the changes that follow orthodontic treatment, therefore preferring the term " post-treatment adjustment [22]." Relapse thus implies a failure to obtain or retain occlusal stabilization [9]. Accordingly, it is imperative that the orthodontist uses a preferably passive retention appliance that either allows the teeth to settle or guides the teeth into their final position during function [22]. The key to a successful

orthodontic practice is the thorough reassessment of treated patients and then careful evaluation of the results [13]. Although there is a multiplicity of factors which contribute to relapse apart from the presence or lack of a retention appliance, it is imperative that the orthodontist choose a retainer that will allow the teeth to remain in a stable position, allow the teeth to settle, and will reduce or prevent the teeth from relapsing to their preexisting occlusion[22].

Literature Review

It is generally recognized that the human dentition is in a dynamic state, continually changing throughout life. Particularly noticeable is the change in the alignment of the lower arch, which may initially be crowded in the early mixed dentition, less so in the years between 8 and 12, and finally, become more crowded after eruption of the second permanent molars. The greatest amount of crowding tends to occur between the ages of 13 and 18. However, this process is said to continue well into the third decade and beyond [21]. Little has also reported that reduction of arch length and inter-canine width is evident. Inter-molar width, if expanded during treatment, tends to return to its original width. The reported changes are greater in the mandibular arch than in the maxillary arch. Most of the arch transformations are seen before age 30 yet crowding continues to take place into the fifth decade [14]. Orthodontists need to recognize that preserving orthodontic corrections can be unpredictable and challenging and that growth, along with tooth alterations and constriction of dental arches, through normal physiological changes, can cause relapse and instability to occur. One must then try to search for a retention appliance that will allow for maintaining periodontal support, provide optimal oral hygiene, and allow functional forces on all teeth [3].

Orthodontists must keep in mind that retention is a challenging endeavor. According to Oppenheim, "Retention is the most difficult problem in orthodontia; in fact it is the problem [18]." Patients face a normal physiological process of arch constriction and crowding and only by some artificial means can orthodontists guarantee success after treatment [3]. Orthodontists must prescribe a retainer that fits each individual patient's needs. The retainer must allow teeth to settle into a stable occlusion in which the function of all teeth are present and the orthodontic corrections made during treatment are stable for several years, especially those years in which crowding is most prevelant.

Over the years, there have been several studies evaluating retention of treated cases. Interestingly enough however, there have been few studies examining the occlusion of finished cases. Orthodontists may contemplate the effect that retention may have on the occlusion of finished cases. It would thus be of interest to investigate the occlusal contacts at the completion of orthodontic treatment, as well as to record the changes that occur following cessation of active orthodontic forces. Gazit and Lieberman performed a study that evaluated occlusal contacts. The experiment consisted of 12 patients that ranged between 14and 16 years of age. Recordings were made, using the photo-occlusion technique, at the time of

appliance removal, one month later, and one year later. These recordings revealed a 56% mean increase in the number of contacts in the first year following orthodontic treatment. In addition, the average number of occlusal contacts, 17.4, found after one year of orthodontic treatment compares favorably with the 19.7 recorded by McNamara and Henry in 1974. In 1982, Riise found an average of 17.1 contacts in his orthodontically treated sample, compared to the 18.4 in a comparable age group of non-orthodontically treated patients [7]. This data was not statistically significant, however it confirms that normal development is more precise in guiding the teeth into occlusion. Retention appliances strive to passively channel the teeth into a stable and functional occlusion, thus mimicking the effects of normal development.

Retention following orthodontic treatment has been defined by Moyers as, "The holding of teeth following orthodontic treatment in the treated position for a period of time necessary for the maintenance of the result [3]. The rationale for holding the teeth in their treated position is to allow for the reorganization of gingival and periodontal tissues, to minimize changes due to growth, and to permit neuromuscular adaptation to corrected tooth position. Orthodontists are cognizant of relapse and the subsequent need for retention. Stability of the occlusion resulting from orthodontic

therapy is clearly a major goal of clinicians [17]. Alternately, instability following orthodontic treatment can be divided into two groups: The first group is characterized by the changes related to growth, maturation, and aging of the dentition and occlusion. The second change is attributed to the inherent instability of the occlusion produced by orthodontic therapy.

Many clinicians have their own theories regarding the stability of treatment and how to preserve orthodontic corrections. Tweed indicated that determining the anterior limits of the denture is the key to stability, and advocated long-term fixed retention of the lower incisors [17]. Little reported that the stability or relapse of the anterior teeth following treatment cannot be predicted by any of the parameters that the researchers investigated, either at the onset or at the end of orthodontic treatment [17]. Sadowsky stressed that some degree of post-treatment relapse in the majority of patients should not be interpreted by practioners as a rationale to end treatment with inferior results [17]. Sadowsky also believed that the data should encourage clinicians to optimally finish cases and provide long -term retention [17]. Zachrisson advocates intentional modification of tooth morphology and cosmetic procedures for long-term stability [17]. Alexander maintains that long-term stability is inseparable from other phases of treatment [17]. This approach includes effective and realistic patient

management at this critical phase of treatment and calls for continuous retention [17].

Orthodontists need to remember that the stability of orthodontically treated dentitions is multi-factorial. Treatment commences with diagnosis and does not culminate with the insertion of retaining devices [17]. The reality of our present knowledge is that no form of treatment guarantees absolute stability, nor does a well treated case, treated by the highest standards, independently assure stability [17]. Removal of orthodontic appliances is by no means the end of orthodontic treatment, rather it is the beginning of the final and very important phase known as retention [15]. It is evident that the majority of orthodontists believe in some form of retention following the removal of orthodontic appliances. Until orthodontists understand more about relapse and stability, it may be necessary for us to seek long-term retention with proper patient education about stability and relapse [17].

Previous retention studies have demonstrated the effectiveness of one retention system over another. Stabilizing teeth in their newly corrected position until the gingival fibers and new bone formation occurs is essential in maintaining a successful case. Tibbetts performed a 6-month retention study which compared the effectiveness of a positioner in addition to a lower bonded 3-3 retainer, Essix retainers, and Hawley retainers [26]. The criteria

that were studied consisted of Angle's classification of the molars, overbite, overjet, maxillary intercuspid width, maxillary intermolar width, maxillary arch width, and mandibular arch width. The results of the experiment revealed that there were no statistically significant differences between the treatment type, nor retainer types, with regards to changes in the criterion mentioned above, during the 6-month retention period studied. In general, the changes that occurred during active treatment remained relatively stable after treatment, during the 6-month period that was observed. All three retention regimes could equally provide adequate retention during a 6 month period following appliance debonding [26]. One of the criteria that was not studied in this experiment was the change in the number of occlusal contacts. Experiments need to evaluate all relevant criteria, especially occlusal contacts, when deciding on a retainer's effectiveness in maintaining the stability as well as allowing the dentition to settle into the ideal functional occlusion. In 1992 Haydar and his colleagues examined changes in the number and location of occlusal contacts in patients retained with a Hawley retainer, a tooth positioner, and finally, non-treated individuals. In this experiment, the investigators believed that orthodontic treatment can be defined as, "obtaining functional occlusion aesthetics, and stability at the end of active treatment." One of the criteria for obtaining functional

occlusion is to have stable centric stops on all teeth in maximum intercuspation [8]. After three months, there was a slight increase in occlusal contacts of the two retainer groups. This finding corresponds with the studies of Durbin and Sadowsky, which demonstrated that settling may continue up to 21 months [6]. However, this slight increase in the treatment groups was not found to be statistically significant when compared to control groups. There was also no significant change in the location of contacts in the anterior and posterior sections after the initial three-month period. This parallels previous studies which show the majority of contacts does not change from time of appliance removal [8]. At the end of orthodontic treatment and three months later, there were no differences between the Hawley and positioner groups when total contacts were compared [8]. Sadowsky, in a similar study, demonstrated that the total number of occlusal contacts increased over a 3-month retention period [6]. Linder also illustrated that the number of occlusal contacts increased following orthodontic treatment during a one year retention study [12]. Haydar and colleagues showed that after the end of active orthodontic therapy, some slight changes occur. However, no considerable change in the number or location of occlusal contacts should be expected. In this respect, an ideal finishing occlusion should be the ultimate goal of active orthodontic therapy.

One should expect minimal alterations to occur during the retention period [8]. For this reason, it is imperative to have a retainer that not only guides the teeth into their natural occlusion but also assists the settling of the dentition. Durbin, Sadowsky, and Razdolsky performed a follow up study to their original 1986 study which evaluated the continued settling of the occlusion of forty patients, 21-months after the active phase of orthodontic treatment [19]. When the results were compared to the previous short term study, it was revealed that continued settling of the occlusion occurred beyond the three months of retention. Few contacts changed their location between the occlusal inclined planes and central grooves. In addition, the number of actual and near contacts increased on the posterior teeth and more near contacts occurred on the anterior teeth. This confirms that minimal settling occurs in the buccolingual direction. Therefore, rather than anticipating a settling of occlusion towards the central groove, an ideal occlusion should be established at the time of appliance removal [19]. Sadowsky and Razdolsky used a number of different retainers, ranging from tooth positioners to Hawley retainers with fixed lower retainers. However, there was no attempt to show the differences in using one retainer over another to produce an occlusion that had the highest number of occlusal contact produced during settling.

Previous experiments have established that the settling of the occlusion does occur following the removal of appliances and continues to transpire well into the retention period. It is important to ask the question, is there a retainer that allows the teeth to settle into an ideal functional occlusion? Sauget and cohorts published a comparison of occlusal contacts after retention with a Hawley retainer versus a clear overlay retainer [24]. According to Sauget, "the best retention device would be one that allows settling but prevents relapse." The experiment evaluated the occlusal contacts of the different retainer groups at the time of debond, retainer insertion, and after three months of retention. At the time of debonding, there was no notable difference between the mean number of total contacts, true contacts, and near contacts. From the time of debonding to the three-month period however, the Hawley retainer group displayed a significant increase in the average number of total contacts. Interestingly, there was no change in the number of anterior contacts. Alternately, the clear overlay retainers displayed no major difference from the time of debonding to the three month period. The authors concluded that the Hawley retainer may encourage posterior tooth eruption whereas the labial wire may have held the anterior teeth, allowing the posterior teeth to extrude. This may explain why the number of anterior contacts remained the same [24]. A similar study by

Lindauder and Shoff, specifically investigated the Essix overlay retainer versus the Hawley retainers [11]. The experiment intended to find which retainer better maintained the orthodontic correction. Occlusal measurements were made on study models before treatment, after treatment, and after 6-months of retention. Further, anterior crowding was assessed using Little's irregularity index. The results revealed that the Essix retainers were as equally effective as the Hawley retainer in sustaining the orthodontic corrections. There were no significant disparities in overbite, incisor irregularity, and overjet between the two groups. Unfortunately, occlusal contacts were not evaluated during the study [11].

There are a multitude of retention appliances used by orthodontists today. The studies cited above provide an insight as to findings that compare these appliances as well as an analysis of their effectiveness in achieving optimal stability. Two commonly prescribed appliances for the maxillary arch are the Hawley and the circumferential wrap-around retainer.

The Hawley is one of the most frequently used retentive devices to date. It was introduced in the early part of the 20th century and its design has remained relatively consistent. Initially, the retainer was comprised of a lingual and palatal vulcanized rubber plate adapted to the lingual surfaces of the teeth, and a labial wire with adjustment loops at the canines. An

assortment of retentive clasps can be used in the posterior segments. The main alteration seen in the modern appliance is the substitution of acrylic for rubber. The palatal or lingual portion of the appliance may be horseshoe shaped or may cover the palate entirely. It should extend distally enough to retain the position of the second molars. The labial bow is constructed from 0.020 to 0.036 inch round stainless steel wire and contacts the labial surfaces of the incisors and, typically, the canines. Occasionally, the position and type of retentive clasps, and the position of the labial bow, are altered to minimize occlusal interferences despite the fact that this is usually impossible to completely eliminate.

The Circumferential maxillary retainer also provides excellent retention. An advantage of this retention device is that the lack of wires passing over the occlusion eradicates the potential for occlusal interferences that may inhibit settling. The Circumferential maxillary retainer is, like the Hawley, constructed from stainless steel round wire that contacts the labial surfaces of the incisors and the buccal surfaces of the posterior teeth as it wraps around the arch. Adjustment loops are generally placed at the canines. Ball clasps can me soldered to the wire distal to the canines to engage the inter-proximal area mesial to the first molar for added retention if required. Similarly, circumferential clasps that engage the mesiobuccal

undercuts on the distal molars can also be used for retention. The palatal acrylic is similar in design as the Hawley retainer.

The purpose of the experiment is to evaluate not only the retentive characteristics of the Hawley versus the Circumferential retainer, but to also determine which retainer allows for a more ideal and functional occlusion. The orthodontic community, as well as the residents and faculty at Oregon Health Sciences University School of Dentistry commonly utilize these retention appliances [10]. To determine whether or not a more ideal functional occlusion is established from either retainer, quantitative comparisons of occlusal contacts will be recorded on treated patients from the orthodontic clinic at debonding, at one month, and after three months of full time retention [11]. Laidlaw demonstrated that at 3 months of retention there were no significant differences in settling or changes in alignment from one retainer group to the other. The previous study recommended that a longer retention period is necessary to determine if one retainer group allows for increased settling to occur [11].

The continued experiment will document occlusal contacts of the patients from the previous study, who are over a year into retention. Anterior segment alignment will be evaluated on study models made at each retention visit. This will be done to determine whether or not any improvements that

may have been detected in the patient's occlusion were achieved at the result of alignment. Furthermore, this continued experiment will grade the finished cases at the time of debonding and compare these results with the graded results at the furthest recorded retention period. The American Board of Orthodontics grading criteria will be applied to these cases to determine if they are being finished to board standards and to also give some insight as to where improvements need to be made. Grading the cases from different retainer groups will allow us to determine if one retainer is more beneficial than the other in achieving a more ideal functional occlusion.

Hypothesis

In the preceding experiment an attempt was made to determine whether a Circumferential or Hawley retainer would produce the greater number of occlusal contacts during the retention period. These findings revealed that there were no statistically significant differences in the number of occlusal contacts from one retainer group to the other. However, this experiment will show that a longer retention period will produce more

occlusal contacts, and allow the teeth to settle into a more ideal and functional occlusion. The null hypothesis is that there is no difference between the Hawley and Circumferential retainers in occlusal settling or alignment.

Materials and methods

Sample Characteristics

At the completion of orthodontic treatment at the Graduate Orthodontic Clinic at Oregon Health Sciences University School of Dentistry, 24 patients from the previous study were prescribed, alternately, Circumferential maxillary retainers or Hawley maxillary retainers in conjunction with a mandibular bonded canine to canine retainer. 18 out of the original 24 patients returned for retention evaluation. The remaining patients were either converted to a different retention appliance or were unable to return due to other obligations. Patients were not chosen nor placed into one retainer group over the other based on any factors. Out of

the 18 patients that returned, 7 patients (6 female and one male) received Hawley retainers and 11 (5 female and 6 male) received Circumferential retainers. Furthermore, a continuation of the previous study was performed in which 10 new patients were prescribed either a Hawley or Circumferential retainer depending on the instructor's request. Out of the 10 new patients admitted into the study, 7 patients (6 female and one male) received circumferential retainers, and 3 patients (2 male and one female) were prescribed Hawley retainers.

Retainers

Immediately following removal of fixed appliances, alginate impressions were made to obtain study models of the dental arches. An additional set of impressions was also made at the time of debonding for fabrication of the retainers. Patients from the previous study were alternately placed in either the Hawley or Circumferential retainer group, while the new patients were placed in a retainer group based on the instructor's decision. A bite registration, to record occlusal contacts, was made using a similar method to that described in previous literature [7]. Vinyl polysiloxane impression material (Regisil PB; Caulk-Dentsply, Milford, Del) was used for the bite registrations. The material was placed over the occlusal surfaces of the mandibular dentition and the patients were

instructed to bite in maximum intercuspation until their teeth met and until the material had set, which was approximately 30 to 40 seconds. A second registration was made to verify accuracy and reproducibility of the bite registration after a substantial rest period. The contacts, appearing as transparencies in the registration material, were then visually compared. If a discrepancy in the pattern of contacts was apparent, an additional registration was performed.

To ensure consistency of design, the same clinician fabricated the retainers in the previous study and these patients maintained their original retainer from the previous study. Further, the 10 new patients that were included in the study had their maxillary retainers produced by an orthodontic laboratory to better insure quality and accuracy of the retainer design. The Hawley retainers were fabricated using 0.030 stainless steel wire for the labial bow and the molar retentive clasps. Adjustment loops were placed at the canines, and the wire passed to the lingual, between the canines and premolar contacts. All attempts were made to adapt the wire to the embrasure to avoid occlusal interferences (see figures 1 and 2). The Circumferential retainers were constructed using 0.036 stainless steel wire. Adjustment loops were placed at the canines. There was no wire passing across the occlusal surface of the teeth (see figures 3 and 4). Retention was

obtained by contouring the wire around the distal molars in the dental arch. The wire had a one-point contact and was not contoured around the teeth in the posterior segment. In all cases of the previous study, the delivery of the retainers was made within three days by the same clinician. However, in the current study, a recently adopted retention protocol was instituted in which temporary upper and lower invisible retainers were manufactured at the time of appliance removal, and final retainers, whether a Hawley or Circumferential retainer, was inserted one week following debond. The labial bows of the retainers were adjusted at the time of insertion to ensure uniform passive contact with the anterior dentition. The retainers were also adjusted to make certain that only light contact of the lower anterior teeth with the palatal acrylic when the posterior teeth were in maximum intercuspation. The lower lingual retainers were bonded using Transbond-XT light cure adhesive by 3M (see figure 5).

All patients from the previous study were recalled for retention evaluation that ranged from 13 to 17 months following appliance removal. The new patients that were admitted into the study followed the same protocol that was instituted in the previous study. Patients were seen for a one-month retention check, as is clinic policy to examine the fit of the retainers and to adjust accordingly. Alginate impressions, for study models,

and bite registration, for evaluation of occlusal contacts, were made as previously described. Three months after retainer insertion, patients were recalled for a retainer check, bite registrations, and alginate impressions. Following this appointment all patients continued with the established retention protocol of the orthodontic clinic.

Bite Registrations

The bite registrations were evaluated for the number of true, near, and total contacts. True contacts being those in which the occlusion perforated the registration material. Near contacts were those that appeared as translucent areas in the registration material. Total contacts were the sum of the true and near contacts. One examiner conducted the initial analysis of the bite registrations in both the current and the previous study and has been kept blind to the appliance being used by each patient. The registrations taken on the recalled patients from the previous study were labeled only with the patient identification number and a number between 13 and 17, which indicated the month the retention check was performed. The new patients that were admitted into the study, however, had registrations that were labeled only with the patient identification number and the letter "d" for debond or a "1" for the month of the retention check. Patients were

separated into retainer groups only after all data was gathered and analysis had begun. Measurements of registrations were taken visually by one operator, in which a standard view box was used to determine if an occlusal contact was true or near. Analyses of the registrations from patients of the previous study and of the new patients enrolled, were tabulated and can be seen in tables 1,3,5, and 7. Statistical analysis of the contact data was also performed and can be seen in tables 2,4,6, and 8.

Model Alignment Analysis

The model analysis for alignment was done using an irregularity index similar to those described in previously published reports. The study models were labeled with a patient identification code and the date the impression for patient confidentiality and objectivity for data analysis. At the one year retention check, horizontal displacement between contact points of the six maxillary anterior teeth were measured on all maxillary models of the patients recalled from the previous study using a Boley gauge. The amount of change in alignment was calculated as a millimeter of change over time. The alignment data was statistically analyzed and evaluated for the prevalence of statistical change in alignment during the retention period (See Table 9 and 10).

ABO Grading System for Dental Casts

The American Board of Orthodontic's grading system for dental casts was developed systematically through a series of four field tests over a period of five years. The board has established 7 criteria, which are graded to determine a final score. These criteria encompass alignment, marginal ridges, buccal/lingual inclination, overjet, occlusal relationships, occlusal contacts, and interproximal contacts. A total score of less than 20 is considered a passing score. A score between 20 and 30 is considered a gray area in which the directors of the board will evaluate other circumstances of the case, like the treatment plan chosen or the diagnosis of the case. A score of 30 or above will automatically receive failing grade. The scores of the patients who were recalled from the previous study can be seen in Tables 11 and 13. A comparison from the time of appliance removal to a year out of appliance removal can be seen in Tables 12 and 14. The scores of the new patients admitted into the study can be seen in Table 15.

Error of the Method

To test the reliability of the bite registration technique, pairs of bite registrations were taken at each visit and compared visually for accuracy in bite patterns. If the registrations did not match, a third registration was obtained.

Maintenance of alignment was analyzed using an irregularity index on study models from canine to canine. Changes in horizontal contact positions between the anterior teeth were measured, and the changes seen for the two retainer groups were statistically compared for significance using a paired t-test (see Table 6).

To ensure impartiality, the dental casts were graded randomly. Once grades were applied to each case, they were then placed in the appropriate retainer group. The Directors of the American Board of Orthodontics, who have spent countless hours developing this system, have established the grading criteria. The usefulness of this grading system depends not only on its objectivity, but more importantly on the validity and reliability of the measurements. The reliability will be insured through the use of a precise

grading instrument, which has been developed by the Directors of the American Board of Orthodontics, and a meticulous instruction sheet, which outlines how to use the instrument to grade the dental casts. More importantly, however, this instruction guide educates the individual on how to determine when deductions are warranted while grading the dental casts. Statistical analysis has been performed on the different retainer groups as well as on the different criteria thought to be involved in settling. Changes in scores and in criteria for the two retainer groups were compared using a paired t- test (see tables 16 and 17).

Results

Occlusal Contacts (Tables 1,3,5 and 7).

The bite registrations for patients in both retainer groups from the previous study showed a wide variation in regards to the number of occlusal contacts present at the time of debond and one year into retention. The Hawley retainer group had an average of 13.7 true contacts with a standard

deviation of 6.1 contacts, and 38.5 total contacts with a standard deviation of 6.5 contacts at the time of debond. At the one-year retention check, the average number of true contacts had increased to 14.3 with a standard deviation of 4.2 contacts, while the number of total contacts had increased to 46.7 with a standard deviation of 7.7 contacts. There was an average increase of 7.0 total from the time of appliance removal to one year into retention. The true contacts, however, showed a –0.27 decrease in contacts from this same time period.

The patients in the continued Circumferential retainer group had an average of 10.6 true contacts at debond with a standard deviation of 3.4 contacts, and 35.2 total contacts with a standard deviation of 8.6 contacts. These same patients one year into retention had an average of 15.0 true contact with a standard deviation of 8.5 contacts, and an average of 56.6 total contacts with a standard deviation of 11.8 contacts. There was an average increase of 17.6 total contacts with a standard deviation of 12.3 contacts from the time of debond to one year into retention. The average number of 5.0 true contacts with a standard deviation of 5.6 contacts increased during this same period (see Tables 1 and 5).

Statistical comparison of settling, achieved by both retainers, was measured by change in the true and total number of contacts from the time

of appliance removal to one year into retention. The data reveals that there was a 21% mean increase in the total number of contacts in the Circumferential retainer group over the Hawley retainer group. Table 2 shows the results of the paired two-tailed t-test, which provides statistically significant data at a 95% confidence level, that the Circumferential retainer produces more total contacts over the Hawley retainer during this time period.

Once it was determined that more total contacts were being produced in the Circumferential group over the Hawley group, the question that needed to be answered was where the contacts were being produced. Table 3 shows the differences in the location of contacts measuring the total number of contacts in the anterior region, which was demarcated from canine to canine, and comparing these contacts with the posterior total contacts (see Table 3). The table shows that there were, on average, 10 more contacts in the posterior region in the Circumferential group when compared to the Hawley group.

The statistical comparison of anterior versus posterior total occlusal contacts at the one-year retention check displayed that there was a 34% mean increase in the Circumferential retainer group compared to the Hawley retainer group in the posterior region. The data is statistically significant,

yielding a 97% confidence level that there were more total occlusal contacts in the posterior region produced in the Circumferential retainer group at the one year retention check (see table 4).

The experiment illustrated that not only was there a difference in the location of the total contacts, but that there was a change in the number of total occlusal contacts from the time of appliance removal to the one year retention check between the two groups. Table 5 shows that on average, there was an increase change of 17. 0 total contacts in the Circumferential group compared to a 7.0 increase change in the Hawley group (see table 5).

The statistical analysis revealed that there was a mean increase of 143% in the change of total contacts in the Circumferential group when compared to the Hawley group from the time of debond to the one year retention check. The data is statistically significant, displaying a 96% confidence level that there are more total contacts being produced from the time of debond up to the one year retention check in the Circumferential appliance group (see table 6).

The study sought to see how the new patients contained in the Circumferential group compared to the patients of the continued study. Both Circumferential groups had their true, near, and total contacts tabulated at

debond and one month into retention. The average of the total contacts in the new Circumferential group at one month was 48.6 compared to the Circumferential patients in the continuing study, which was 38.9 total contacts (see table 7).

The statistical analysis of true and total contacts between the differing Circumferential retainer groups displayed that at one month, the new patients admitted into the study, had a 25% mean increase in total contacts when compared to the Circumferential group already admitted. The data is statistically significant, giving a confidence measure of 97.5% (see table 8).

Alignment Analysis (Table 9 and 10)

The change of maxillary canine-to-canine alignment over the course of the retention period was measured in order to determine if one retainer allowed better retention of anterior alignment over the other. All cases were evaluated for changes in the horizontal position of anterior contact points. Patients were examined at debond, 3 months into retention, and one year into retention. At one year, there was some alignment change, however both the Hawley and the Circumferential group were near 1.0 mm in total alignment displacement (see table 9).

Statistical analysis was done using a paired two-tailed t-test. The test showed no significance in alignment change in either retention group (see table 10).

ABO Grading system for Dental Casts. (Tables 11, 12, 13, 14, and 15)

The dental casts of the patients enrolled in the previous study and of those admitted into the new study were graded at the time of debond as well as at one month, for the new patients, and one year for the currently enrolled patients. Table 11 displays the averages and standard deviations of the different board criteria, including the overall ABO score for the previously enrolled patients of the Hawley group at debond, and one year into retention. The average total score at appliance removal was 34.0. This decreased to an average of 28.0 at the one-year retention check. Table 12 depicts the changes that occurred in certain criteria, such as marginal ridges, occlusal contacts, and buccal/lingual inclinations, and the overall score from the patients in the Hawley group. The average change in ABO score from debond to one year had decreased by 6 points.

The dental casts of the Circumferential group in the previous study were graded using the ABO standards, in which certain criteria, as described earlier, were evaluated. Table 13 illustrates that the average total ABO score was 26 at appliance removal and 23 at one year into retention. The data in table 14 shows that there was an average decrease of 2 points from the total ABO score from the time of debond to one year into retention. Changes of other criteria depicted in table 14 were minimal.

The dental casts of the newly enrolled Circumferential group were also graded as described above. Table 15 illustrates that the average ABO score at the time of debond for the newly enrolled Circumferential group was 26.0 and at the one month retention check this average total ABO score decreased to 23.0 (see table 15).

Statistical comparison of the total ABO score at debond, at one year into retention, and the change in score during this time period was performed on both the Hawley and Circumferential groups of the previous study. At debond, the Hawley group had a 30% higher increase in ABO score when compared to the Circumferential group. The data is statistically significant, yielding a 98% confidence level. The change in ABO score, and the score at one year were not statistically significant (see table 16).

Statistical comparison of changes that occurred in certain ABO criteria, consisting of occlusal contacts, marginal ridges, and buccal/lingual inclinations, were evaluated between the Hawley and Circumferential groups of the previous study. There was no statistical significance seen in any of the criteria between the two retention groups.

Discussion

The previous study showed that that the validity of the measurements obtained was promising, as the total number of occlusal contacts at debond was similar to those reported by Radolsky and Sadowsky in their 1989 study of occlusal contacts following orthodontic treatment [18]. Results from this study also showed that the number of total contacts in the Circumferential group at debond were similar to the study performed by Laidlaw [10]. However, this experiment showed that data was statistically significant ($P<.05$) in settling characteristics between Hawley and Circumferential groups, as well as the newly admitted Circumferential group when compared to the previous Circumferential group. The average number of the true contacts, one year into retention, was similar between the two retention groups. However, when the total occlusal contacts were compared between the Circumferential and Hawley groups, it was shown that the

Circumferential group produced a greater number of total occlusal contacts at the one year retention check than did the Hawley group. The data was statistically significant.

In the previous study there was no attempt to determine the location of the contacts. Once it was determined that there was a difference in the total number of contacts one year into retention, the study sought to determine where the increase in the total number of contacts was being produced. The data revealed that the total posterior contacts in the Circumferential groups was statistically significant ($P<.05$) when compared to Hawley group at the one year retention check.

It was thought that a comparison between the two retainer groups in reference to the change in occlusal contacts should be evaluated from the time of debond to the one year retention check. When one looked at the average change of the total contacts in the Circumferential group (17.0) compared to the Hawley group (7.0), it was apparent that the Circumferential group produced more total contact points from the time of debond to the one year retention check. Table 6 reveals that the data was statistically significant, proving that the Circumferential produced more total contacts during this time period.

When the Circumferential group of the previous study was compared to Circumferential group of the new study, it was shown that at one month, the total contacts of the newly admitted Circumferential group were significantly greater than the other Circumferential group. The data appearing in table 8 shows statistical significance in total contacts when comparing the new circumferential group to the previous group. The reason for this difference could have been in the way the retainers were constructed even though the designs were the same. It is plausible that the orthodontic laboratory could have produced a better retainer than the previous resident.

There were no significant differences in the retentive properties of the two different retainer designs when anterior alignment was measured. The previous study, conducted by Laidlaw, showed that there were minimal changes in four out of the twenty-four patients, and that no changes were greater than 1.0mm.[10] The continued study revealed that, on average, there was a 1.1mm change in the Circumferential group compared to a 0.9mm average change in alignment in the Hawley group. There was no statistical significance between the two groups when alignment was compared at the one-year retention check.

The current study, using the American Board of Orthodontics Grading criteria, illustrated that there were no significant changes in certain criteria

thought to be involved in settling when compared between the two retainer groups and when compared from the time of debond to the one-year retention check. The only statistical change was that the Hawley group started out with a higher score, when compared to the Circumferential group, and that the decrease in score was greater in the Hawley group. This was probably due to the fact that the Hawley group had more room to improve in score than the Circumferential group. One interesting fact seen in grading the dental casts was that the average total ABO score of the new Circumferential group at debond was identical to the average total score of old Circumferential group at the same time period. At the one-month retention check, the average total score of the new Circumferential group was compared to the average total score of the old Circumferential group at the one year retention check. The results revealed that the averages were quite similar, meaning that cases graded at one month may have the same grade as those graded in one year.

Conclusion

This study demonstrated statistically significant differences in the settling properties of the Hawley compared to the Circumferential retainer groups from the time of appliance removal to one year into retention. The

sample size consisted of 18 out of the 24 patients from the previous retention study, performed by Dr. Laidlaw at the graduate orthodontic clinic at Oregon Health Sciences University [10]. The new Circumferential patients, who were admitted into the study, also demonstrated an increase in settling when compared to the previous Circumferential patients one month into retention. These findings suggest that the Circumferential retainer allows for settling to occur in the posterior occlusal table. However, the ABO criteria that the investigator thought was involved in settling, changed very little and did not seem to influence the degree of settling. When looking at the ABO scores at debond and then one year into retention, the average total scores did improve, explaining that settling most likely did occur to some extent. Although the criteria thought to be involved in settling showed minor improvements, the ABO criteria as an aggregate did improve one year into retention which yielded a significant change in the ABO scores. Even though the sample size was small, the author believes that at this time, the Circumferential retainer can be recommended over the Hawley for the sake of settling. However, there is no strong evidence that alignment benefits more from the use of this retainer.

TABLE 1. CONTACT TABULATION: VISUAL ANALYSIS

HAWLEY

Hawley Debond	True contacts	Near Contacts	total contacts
5254m171 d	24	22	46
5014m167 d	13	25	38
4514d156 d	15	31	46
5187rk172 d	7	29	36
5033d166 d	14	21	35
5482m177 d	22	21	43
5229d172 d	12	23	35
5330y172 d	4	31	35
4777d159 d	6	19	25
5264m172 d	12	31	33
4754d162 d	11	26	37
5171r171 d	17	26	43
4967rk168 d	21	27	48
Average	13.6923077	25.5384615	38.4615385
SD	6.14253769	4.1556264	6.4629119

Hawley 1 year	True contacts	Near Contacts	total contacts
5254m171 (14)	17	32	49
5014m167 (14)	19	30	49
4514d156 (15)	13	30	43
5033d166 (15)	9	33	42
5482m177 (13)	16	36	52
5229d172 (15)	20	33	53
5330y172 (10)	10	43	53
4777d159 (13)	7	22	29
5264m172 (13)	17	40	57
5171r171 (13)	15	27	42
4967rk168 (13)	14	31	45
Avg	14.2727273	32.4545455	46.7272727
SD	4.17350953	5.78556197	7.73422147

CIRCUMFERENTIAL

Circum Debond	True contacts	Near Contacts	total contacts
5127d168 d	4	38	42
5261l175 d	10	27	37
5186y172 d	12	19	31
ug311 d	16	38	54
5174g171 d	13	21	34
5096d168 d	10	17	27
5157d172 d	9	28	37
4993g168 d	12	10	22
5107rk161 d	5	27	32
5402g178d	13	28	41
5085l169d	13	17	30
Average	10.6363636	24.5454545	35.1818182
SD	3.58532362	8.75629644	8.58857592

Circum 1 year	True contacts	Near Contacts	total contacts
5127d168 (17)	13	58	71
5261l175 (16)	16	41	57
5157d172 (16)	7	42	49
5107rk161 (14)	4	31	35
5402g178 (15)	19	41	60
5085l169(13)	16	50	66
UG 311(17)	30	28	58
Avg	15	41.5714286	56.5714286
SD	8.48528137	10.3094963	11.7878065

Table 1 displays case identification numbers, which end in a digit corresponding to phase of treatment. The letter d represents the debond appointment, while the numbers 13-17 represent one year retention checks. The averages and standard deviations are displayed for the true, near, and total contact points.

TABLE 2. STATISTICAL ANALYSIS OF HAWLEY VS CIRCUMFERENTIAL RETENTION APPLIANCE

Total Contacts

t-Test: Two-Sample Assuming Equal Variances

	H Appliance	*C Appliance*
Mean	46.7272727	56.5714286
Variance	59.8181818	138.952381
Observations	11	7
Pooled Variance	89.4935065	
Hypothesized Mean Difference	0	
df	16	
t Stat	-2.1522456	
P(T<=t) one-tail	0.02349429	
t Critical one-tail	1.74588422	
P(T<=t) two-tail	0.04698859	
t Critical two-tail	2.11990482	

True Contacts

t-Test: Two-Sample Assuming Equal Variances

	H Appliance	*C Appliance*
Mean	14.2727273	15
Variance	17.4181818	72
Observations	11	7
Pooled Variance	37.8863636	
Hypothesized Mean Difference	0	
df	16	
t Stat	-0.2443796	
P(T<=t) one-tail	0.40502155	
t Critical one-tail	1.74588422	
P(T<=t) two-tail	0.8100431	
t Critical two-tail	2.11990482	

Table 2 shows results of the unpaired t-test analysis of changes in true and total contact points from debond to 1 year in the Hawley vs. the Circumferential retention groups.

TABLE 3. ANTERIOR/ POSTERIOR CONTACT TABULATION

Hawley 1 year	Ant contacts	Post Contacts	total contacts
5254m171 (14)	14	35	49
5014m167 (14)	15	34	49
4514d156 (15)	18	25	43
5033d166 (15)	17	25	42
5482m177 (13)	14	38	52
5229d172 (15)	17	36	53
5330y172 (10)	13	40	53
4777d159 (13)	11	18	29
5264m172 (13)	10	47	57
5171r171 (13)	10	32	42
4967rk168 (13)	15	30	45
Avg	14	32.7272727	46.7272727
SD	2.79284801	8.03854351	7.73422147

Circum 1 year	Ant contacts	Post Contacts	total contacts
5127d168 (17)	14	57	71
5261l175 (16)	12	45	57
5157d172 (16)	16	33	49
5107rk161 (14)	10	25	35
5402g178 (15)	14	46	60
5085l169(13)	18	48	66
UG 311(17)	8	50	58
Avg	13.1428571	43.4285714	56.5714286
SD	3.43649877	10.8452316	11.7878065

Table 3 differentiated total contact points into anterior and posterior contacts after 1 year retention..

TABLE 4. STATISTICAL ANALYSIS OF HAWLEY VS CIRCUMFERENTIAL RETENTION APPLIANCE

Anterior Contacts

t-Test: Two-Sample Assuming Equal Variances

	H Appliance	*C Appliance*
Mean	14	13.1428571
Variance	7.8	11.8095238
Observations	11	7
Pooled Variance	9.30357143	
Hypothesized Mean Difference	0	
df	16	
t Stat	0.58121588	
P(T<=t) one-tail	0.28459648	
t Critical one-tail	1.74588422	
P(T<=t) two-tail	0.56919297	
t Critical two-tail	2.11990482	

Posterior Contacts

t-Test: Two-Sample Assuming Equal Variances

	H Appliance	*C Appliance*
Mean	32.7272727	43.4285714
Variance	64.6181818	117.619048
Observations	11	7
Pooled Variance	84.4935065	
Hypothesized Mean Difference	0	
df	16	
t Stat	-2.407875	
P(T<=t) one-tail	0.01423469	
t Critical one-tail	1.74588422	
P(T<=t) two-tail	0.02846938	
t Critical two-tail	2.11990482	

Table 4 shows results of the unpaired t-test analysis of changes in total contact points of anterior and posterior regions from debond to 1 year in the Hawley vs. the Circumferential retention groups.

Table 5. COMPARISON OF CONTACT TABULATIONS AND CHANGES IN THE HAWLEY VS. CIRCUMFERENTIAL RETAINER GROUP FROM DEBOND TO ONE YEAR IN RETENTION.

Hawleys debond	True contacts	Near Contacts	total contacts
5254m171 d	24	22	46
5014m167 d	13	25	38
4514d156 d	15	31	46
5033d166 d	14	21	35
5482m177 d	22	21	43
5229d172 d	12	23	35
5330y172 d	4	31	35
4777d159 d	6	19	25
5264m172 d	12	31	33
5171r171 d	17	26	43
4967rk168 d	21	27	48
Average	14.5454545	25.1818182	38.8181818
SD	6.26679561	4.4004132	7.01167857

Change from debond to 1 year

Hawleys debond	True contacts	Near Contacts	total contacts
5254m171 d	-7	10	3
5014m167 d	6	5	11
4514d156 d	-2	-1	-3
5033d166 d	-5	12	7
5482m177 d	-6	15	9
5229d172 d	8	10	18
5330y172 d	6	12	18
4777d159 d	1	3	4
5264m172 d	5	9	14
5171r171 d	-2	1	-1
4967rk168 d	-7	4	-3
Average	-0.2727273	7.27272727	7
SD	5.72871555	5.13986204	7.74596669

Hawleys 1 year	True contacts	Near Contacts	total contacts
5254m171 (14)	17	32	49
5014m167 (14)	19	30	49
4514d156 (15)	13	30	43
5033d166 (15)	9	33	42
5482m177 (13)	16	36	52
5229d172 (15)	20	33	53
5330y172 (10)	10	43	53
4777d159 (13)	7	22	29
5264m172 (13)	17	40	57
5171r171 (13)	15	27	42
4967rk168 (13)	14	31	45
Avg	14.2727273	32.4545455	46.7272727
SD	4.17350953	5.78556197	7.73422147

Circum debond	True contacts	Near Contacts	total contacts
5127d168 d	4	38	42
5261l175 d	10	27	37
5157d172 d	9	28	37
5107rk161 d	5	27	32
5402g178d	13	28	41
5085l169d	13	17	30
UG311 d	16	38	54
Average	9	27.5	36.5
SD			

Change from debond to 1 year

Circumferential	True contacts	Near Contacts	total contacts
5127d168	9	20	29
5261l175	6	14	20
5157d172	-2	14	12
5107rk161	-1	4	3
5402g178	6	13	19
5085l169	3	33	36
UG 311	14	-10	4
Average	5	12.5714286	17.5714286
SD	5.59761854	13.2898099	12.286268

Circum 1 year	True contacts	Near Contacts	total contacts
5127d168 (17)	13	58	71
5261l175 (16)	16	41	57
5157d172 (16)	7	42	49
5107rk161 (14)	4	31	35
5402g178 (15)	19	41	60
5085l169(13)	16	50	66
UG 311(17)	30	28	58
Avg	15	41.5714286	56.5714286
SD	8.48528137	10.3094963	11.7878065

Table 5 shows the averages and standard deviations of the true,near,and total contact points. The data also displays the changes in these contact points that occurred from debond to one year into retention.

Table 6. STATISTICAL ANALYSIS OF THE CHANGE IN OCCLUSAL CONTACT POINTS FROM DEBOND TO ONE YEAR INTO RETENTION BETWEEN HAWLEY AND CIRCUMFERENTIAL RETAINER GROUPS.

Change in True Contacts

Sample Assuming Equal Variances

	H Appliance	*C Appliance*
Mean	-0.2727273	5
Variance	32.8181818	31.3333333
Observations	11	7
Pooled Variance	32.2613636	
othesized Mean Differe	0	
df	16	
t Stat	-1.9200081	
P(T<=t) one-tail	0.03643324	
t Critical one-tail	1.74588422	
P(T<=t) two-tail	0.07286647	
t Critical two-tail	2.11990482	

Change in Total Contacts

t-Test: Two-Sample Assuming Equal Variances

	H Appliance	*C Appliance*
Mean	7	17.5714286
Variance	60	150.952381
Observations	11	7
Pooled Variance	94.1071429	
Hypothesized Mean Differe	0	
df	16	
t Stat	-2.2538837	
P(T<=t) one-tail	0.01928987	
t Critical one-tail	1.74588422	
P(T<=t) two-tail	0.03857975	
t Critical two-tail	2.11990482	

Table 6 shows the results of the unpaired t-test analysis of changes in true and total contact points from debond to one year into retention between Hawley and Circumferential retention groups.

Table 7. COMPARISON OF CONTACT TABULATIONS OF NEW PATIENTS TO THOSE OF THE PREVIOUS STUDY.

CIRCUMFERENTIAL NEW

Debond	True contacts	Near Contacts	total contacts
5401-G-178-C (d)	9	34	43
5621-Y-182-C (d)	9	35	44
4785-Y-186-C (d)	11	33	44
5611-R-184-C (d)	5	18	23
5547-R-176-C (d)	7	39	46
5351-D-171-C (d)	2	37	39
5625-MM-187-C (d)	10	49	59
Avg	7.57142857	35	42.5714286
SD	3.15473944	9.21954446	10.6592236

1 month	True contacts	Near Contacts	total contacts
5401-G-178-C (1)	13	39	52
5621-Y-182-C (1)	10	39	49
4785-Y-186-C (1)	13	35	48
5611-R-184-C (1)	21	28	49
5547-R-176-C (1)	20	36	56
5351-D-171-C (1)	10	28	38
Avg	14.5	34.1666667	48.6666667
SD	4.84767986	5.0365332	5.98887858

CIRCUMFERENTIAL OLD

Debond	True contacts	Near Contacts	total contacts
5127d168 d	4	38	42
5261l175 d	10	27	37
5186y172 d	12	19	31
ug311 d	16	38	54
5174g171 d	13	21	34
5096d168 d	10	17	27
5157d172 d	9	28	37
4993g168 d	12	10	22
5107rk161 d	5	27	32
5402g178d	13	28	41
5085l169d	13	17	30
Avg	10.6363636	24.5454545	35.1818182
SD	3.58532362	8.75629644	8.58857592

1 month	True contacts	Near Contacts	total contacts
5127d168 1	20	31	51
5261l175 1	6	26	32
5186y172 1	14	23	37
ug311 1	18	33	51
5174g171 1	7	24	31
5096d178 1	11	23	34
5157d172 1	12	26	38
4993g168 1	16	15	31
5107rk161 1	6	24	30
5402g178 1	15	28	43
5085l169 1	19	31	50
Avg	13.0909091	25.8181818	38.9090909
SD	5.12746615	4.99636231	8.44339441

Table 7 shows the averages and standard deviations of the true, near , and total contact points of patients in differing Circumferential retainer groups.

Table 8. STATISTICAL ANALYSIS OF DIFFERING CIRCUMFERENTIAL RETAINER GROUPS.

Total Contacts (Debond)
t-Test: Two-Sample Assuming Equal Variances

	Investigator1	*Investigator2*
Mean	42.5714286	35.1818182
Variance	113.619048	73.7636364
Observations	7	11
Pooled Variance	88.7094156	
Hypothesized Mean D	0	
df	16	
t Stat	1.62272823	
P(T<=t) one-tail	0.06209164	
t Critical one-tail	1.74588422	
P(T<=t) two-tail	0.12418328	
t Critical two-tail	2.11990482	

True Contacts (Debond)
t-Test: Two-Sample Assuming Equal Variances

	Investigator1	*Investigator2*
Mean	7.57142857	10.6363636
Variance	9.95238095	12.8545455
Observations	7	11
Pooled Variance	11.7662338	
Hypothesized Mean D	0	
df	16	
t Stat	-1.8480412	
P(T<=t) one-tail	0.04158337	
t Critical one-tail	1.74588422	
P(T<=t) two-tail	0.08316674	
t Critical two-tail	2.11990482	

Total Contacts (1 Month)
t-Test: Two-Sample Assuming Equal Variances

	Investigator1	*Investigator2*
Mean	48.6666667	38.9090909
Variance	35.8666667	71.2909091
Observations	6	11
Pooled Variance	59.4828283	
Hypothesized Mean D	0	
df	15	
t Stat	2.49263558	
P(T<=t) one-tail	0.01242734	
t Critical one-tail	1.75305104	
P(T<=t) two-tail	0.02485468	
t Critical two-tail	2.13145086	

True Contacts (1 Month)
t-Test: Two-Sample Assuming Equal Variances

	Investigator1	*Investigator2*
Mean	14.5	13.0909091
Variance	23.5	26.2909091
Observations	6	11
Pooled Variance	25.3606061	
Hypothesized Mean D	0	
df	15	
t Stat	0.55132376	
P(T<=t) one-tail	0.29476535	
t Critical one-tail	1.75305104	
P(T<=t) two-tail	0.5895307	
t Critical two-tail	2.13145086	

Table 8 shows results of the unpaired t-test analysis of changes in total and true contact points from debond to 1month in differing Circumferential retainer groups.

Table 9. ANTERIOR ALIGNMENT

	debond	1 month	3 months	1 Year +
5096 D 178C	0	0	0	
5157 D 172C	0	0	0	0.7
5107 RK 161C	0	1	1	1.1
5402 G 178C	0	0	0	1.9
5174 G 171C	0	0.5	1	
5261 L 175C	0	0	0.5	2.4
5186 Y 172C	0	0	0	
5177 G 172C	0	0	0	
5127 D 168C	0	0	0	0.2
4993 G 168C	0	0	0	
5085 L 169 C	0	0	0	0.3
Average	0.00	0.14	0.23	1.1

	debond	1 month	3 months	1 Year +
5264 M 172H	0	0	0	0.9
5229 D 172H	0	0	0	0.6
5171 R 171H	0	0	0	0.6
4777 D 159H	0	0	0	0.5
4967 RK 168H	0	0	0	1.4
5330 Y 172H	0	0	0	0.6
5033 D 166H	0	0.5	0.5	0.8
4754 D 162H	0	0	0	
5014 M 167H	0	0	0	1.6
5482 M 177H	0	0	0	1.3
5187 RK 172H	0	0	0	
5254 M171H	0	0	0	0.4
4514 D 156H	0	0	0	1.0
Average	0.00	0.04	0.04	0.9

Table 9 shows the change in canine to canine alignment measured in millimeters from debond to one year into retention. Alignment was measured as the change in horizontal position of adjacent contact points.

Table 10. ALIGNMENT CHANGE ANALYSIS

t-Test: Two-Sample Assuming Equal Variances

	Circum	*Hawley*
Mean	1.1	0.88181818
Variance	0.788	0.15963636
Observations	6	11
Pooled Variance	0.36909091	
Hypothesized Mea	0	
df	15	
t Stat	0.70761884	
P(T<=t) one-tail	0.24501572	
t Critical one-tail	1.75305104	
P(T<=t) two-tail	0.49003143	
t Critical two-tai	2.13145086	

Table 10 shows the statistical analysis of the alignment change from debond to one year in the Hawley vs. Circumferential appliance groups.

Table 11. AMERICAN ASSOCIATION OF ORTHODONTICS GRADING CRITERIA OF PATIENTS ENROLLED IN THE HAWLEY GROUP AT THE TIME OF DEBOND AND ONE YEAR INTO RETENTION.

Hawleys Debond	Alignment		Maginal Ridge		Bucal/ Lingual Inclination		Occlusal Contact	Occlusal relationship	Overjet	Interproximal Contact		Total
	Mand	Max	Mand	Max	Mand	Max				Mand	Max	
5254m171	3	3	3	2	4	3	3	5	6	2	2	36
5014m167	2	2	2	4	1	2	3	2	7	0	2	27
4514d156	3	1	5	4	7	7	4	3	13	0	4	51
5033d166	3	1	2	2	2	2	4	6	3	1	4	30
5482m177	2	3	1	1	3	2	4	4	8	0	1	29
5229d172	3	2	7	2	1	7	5	1	3	4	3	38
5330y172	2	0	7	5	3	4	9	1	1	0	0	32
4777d159	2	2	1	2	2	1	8	5	4	2	3	32
5264m172	1	2	6	3	6	5	9	2	8	0	1	43
5171r171	1	3	1	3	6	2	3	3	8	0	2	32
4967rk168	4	3	2	1	0	0	6	5	3	2	2	28
Average	2.3636	2	3.3636	2.6364	3.1818	3.1818	5.272727	3.363636364	5.81818	1	2.1818	34.364
SD	0.9244	1	2.4196	1.2863	2.316	2.316	2.37027	1.747725795	3.42982	1.3416	1.2505	7.2563

Hawleys 1 year	Alignment		Maginal Ridge		Bucal/ Lingual Inclination		Occlusal Contact	Occlusal relationship	Overjet	Interproximal Contact		Total
	Mand	Max	Mand	Max	Mand	Max				Mand	Max	
5254m171	2	1	4	1	3	4	1	4	4	0	0	24
5014m167	3	1	3	1	0	4	1	1	3	0	1	18
4514d156	4	3	2	2	5	7	9	6	8	0	0	46
5033d166	1	2	2	0	1	2	1	5	0	0	4	18
5482m177	6	1	3	1	2	0	7	5	11	0	1	37
5229d172	3	2	3	1	3	3	1	1	1	0	0	18
5330y172	4	1	5	6	4	3	5	1	3	0	0	32
4777d159	3	2	3	0	2	2	0	9	8	1	3	33
5264m172	1	1	2	1	3	3	7	3	6	0	0	27
5171r171	3	2	3	2	5	5	13	3	4	0	0	40
4967rk168	4	2	2	1	1	3	0	4	2	0	0	19
Average	3.0909	1.6364	2.9091	1.4545	2.6364	3.2727	4.090909	3.818181818	4.54545	0.0909	0.8182	28.364
SD	1.446	0.6742	0.9439	1.6348	1.6293	1.7939	4.392142	2.442055766	3.35749	0.3015	1.4013	9.9325

Table 11 shows the scoring of different criteria established by the ABO, which displays the averages and standard deviations of the different criteria from the Hawley patients at debond and one year into retention.

Table 12. CHANGES IN SCORES AND CRITERIA THOUGHT TO BE INVOLVED IN SETTLING.

Hawleys	ABO score 1year	ABO score debond	Change in ABO score	Change in Mar Ridge	Change in Buc/Ling Inclination	Change in Occl Contacts
5254m171	24	36	-12	0	0	-2
5014m167	18	27	-9	-2	1	-2
4514d156	46	51	-5	-5	-2	5
5033d166	18	30	-12	-2	-1	-3
5482m177	37	29	8	2	-3	3
5229d172	18	38	-20	-5	-2	-4
5330y172	32	32	0	-1	0	-4
4777d159	33	32	1	0	1	-8
5264m172	27	43	-16	-6	-5	-2
5171r171	40	32	8	1	2	10
4967rk168	19	28	-9	0	4	-6
Average	28.3636364	34.3636364	-6	-1.6363636	-0.4545455	-1.1818182
SD	9.93249946	7.25634519	9.29516003	2.65603943	2.50454133	5.21187455

Table 12 shows the changes in averages and standard deviation of scores and criteria that occurred in the Hawley group from the time of debond to one year into retention

Table 13. AMERICAN ASSOCIATION OF ORTHODONTICS GRADING CRITERIA OF PATIENTS ENROLLED IN THE CIRCUMFERENTIAL GROUP AT THE TIME OF DEBOND AND ONE YEAR INTO RETENTION.

Circumferential debond	Alignment		Maginal Ridge		Bucal/ Lingual Inclination		Occlusal Contact	Occlusal relationship	Overjet	Interproximal Contact		Total
	Mand	Max	Mand	Max	Mand	Max				Mand	Max	
5127d168	1	1	6	3	3	1	2	2	0	1	0	20
5261l175	1	0	6	2	3	4	6	3	8	1	1	35
5157d172	3	2	3	5	4	0	2	3	1	0	1	24
5107rk161	2	2	0	1	3	2	1	2	6	0	0	19
5402g178	3	3	4	2	3	1	5	5	2	1	2	31
5085l169	2	2	3	3	3	3	4	3	5	0	0	28
UG 311	3	2	1	1	3	2	3	4	6	0	0	25
Average	2.1429	1.7143	3.2857	2.4286	3.1429	1.8571	3.285714	3.142857143	4	0.4286	0.5714	26
SD	0.8997	0.9512	2.2887	1.3973	0.378	1.3452	1.799471	1.069044968	3	0.5345	0.7868	5.7735

Circumferential 1 year	Alignment		Maginal Ridge		Bucal/ Lingual Inclination		Occlusal Contact	Occlusal relationship	Overjet	Interproximal Contact		Total
	Mand	Max	Mand	Max	Mand	Max				Mand	Max	
5127d168	1	1	3	3	3	5	4	0	0	0	0	20
5261l175	4	3	7	3	6	3	4	0	3	1	1	35
5157d172	0	3	5	1	2	2	3	0	1	1	0	18
5107rk161	1	2	2	2	3	2	0	2	8	0	0	22
5402g178	7	2	4	2	2	2	2	3	3	0	0	27
5085l169	1	2	3	2	4	4	3	0	3	0	0	22
UG 311	3	1	0	1	3	3	2	3	2	0	0	18
Average	2.4286	2	3.4286	2	3.2857	3	2.571429	1.142857143	2.85714	0.2857	0.1429	23.143
SD	2.4398	0.8165	2.2254	0.8165	1.3801	1.1547	1.397276	1.463850109	2.54484	0.488	0.378	6.0671

Table 13 shows the scoring of different criteria established by the ABO, which displays the averages and standard deviations of the different criteria from the Circumferential patients at debond and one year into retention.

Table 14. CHANGES IN SCORES AND CRITERIA THOUGHT TO BE INVOLVED IN SETTLING.

Circumferential	ABO score 1year	ABO score debond	1year - Debond	Change in Mar Ridge	Change in Buc/Ling Inclination	Change in Occl Contacts
5127d168	20	20	0	-3	4	2
5261l175	35	35	0	2	2	-2
5157d172	18	24	-6	-2	0	1
5107rk161	22	19	3	3	0	-1
5402g178	27	31	-4	0	0	-3
5085l169	22	28	-6	-1	2	-1
UG 311	18	25	-7	-1	1	-1
Average	23.1428571	26	-2.8571429	-0.2857143	1.28571429	-0.7142857
SD	6.06708528	5.77350269	3.84831441	2.13808994	1.49602648	1.70433621

Table 14 shows the changes in averages and standard deviation of scores and criteria that occurred in the Circumferential group from the time of debond to one year into retention

Table 15. AMERICAN ASSOCIATION OF ORTHODONTICS GRADING CRITERIA OF PATIENTS ENROLLED IN THE CIRCUMFERENTIAL GROUP AT THE TIME OF DEBOND AND ONE MONTH INTO RETENTION.

Circumferential debond	Alignment		Maginal Ridge		Bucal/ Lingual Inclination		Occlusal Contact	Occlusal relationship	Overjet	Interproximal Contact		Total
	Mand	Max	Mand	Max	Mand	Max				Mand	Max	
5401-G-178-C (d)	2	4	3	5	2	1	6	2	7	0	1	33
5621-Y-182-C (d)	3	2	4	4	3	1	7	1	1	0	1	27
4785-Y-186-C (d)	2	3	0	2	4	5	6	2	1	1	0	26
5611-R-184-C (d)	2	1	1	1	5	3	3	0	0	0	0	16
5547-R-176-C (d)	6	2	6	0	6	4	3	3	1	0	0	31
5351-D-171-C (d)	3	2	0	4	1	7	5	4	3	1	1	31
5625-MM-187-C (d)	2	1	0	0	2	1	6	3	3	0	0	18
Average	2.8571	2.1429	2	2.2857	3.2857	3.1429	5.142857	2.142857143	2.28571	0.2857	0.4286	26
SD	1.4639	1.069	2.3805	2.0587	1.7995	2.3401	1.573592	1.345185418	2.36039	0.488	0.5345	6.6332

Circumferential 1 month	Alignment		Maginal Ridge		Bucal/ Lingual Inclination		Occlusal Contact	Occlusal relationship	Overjet	Interproximal Contact		Total
	Mand	Max	Mand	Max	Mand	Max				Mand	Max	
5401-G-178-C (1)	3	2	3	4	2	1	3	2	2	0	0	22
5621-Y-182-C (1)	2	0	2	3	1	2	5	0	0	0	0	15
4785-Y-186-C (1)	3	2	1	4	4	5	11	1	3	0	0	34
5611-R-184-C (1)	1	1	1	1	4	3	3	0	0	0	0	14
5547-R-176-C (1)	7	2	4	2	2	2	2	3	3	0	0	27
5351-D-171-C (1)	3	0	0	2	3	7	7	5	3	0	0	30
Average	3.1667	1.1667	1.8333	2.6667	2.6667	3.3333	5.166667	1.833333333	1.83333	0	0	23.667
SD	2.0412	0.9832	1.472	1.2111	1.2111	2.2509	3.371449	1.940790217	1.47196	0	0	8.1158

Table 15 shows the scoring of different criteria established by the ABO, which displays the averages and standard deviations of the different criteria from the Circumferential patients at debond and one month into retention.

Table 16. STATISTICAL ANALYSIS OF THE AMERICAN ASSOCIATION OF ORTHODONTICS GRADING CRITERIA AS APPLIED TO THE CIRCUMFERENTIAL AND HAWLEY RETAINER GROUPS.

ABO score debond

t-Test: Two-Sample Assuming Equal Variances

	H Appliance	*C Appliance*
Mean	34.3636364	26
Variance	52.6545455	33.3333333
Observations	11	7
Pooled Variance	45.4090909	
Hypothesized Mean Difference	0	
df	16	
t Stat	2.56704126	
P(T<=t) one-tail	0.01033891	
t Critical one-tail	1.74588422	
P(T<=t) two-tail	0.02067781	
t Critical two-tail	2.11990482	

ABO score 1 year retention

t-Test: Two-Sample Assuming Equal Variances

	H Appliance	*C Appliance*
Mean	28.3636364	23.1428571
Variance	98.6545455	36.8095238
Observations	11	7
Pooled Variance	75.4626623	
Hypothesized Mean Difference	0	
df	16	
t Stat	1.24302074	
P(T<=t) one-tail	0.11588399	
t Critical one-tail	1.74588422	
P(T<=t) two-tail	0.23176798	
t Critical two-tail	2.11990482	

Change in ABO score

t-Test: Two-Sample Assuming Equal Variances

	H Appliance	*C Appliance*
Mean	-6	-2.8571429
Variance	86.4	14.8095238
Observations	11	7
Pooled Variance	59.5535714	
Hypothesized Mean Difference	0	
df	16	
t Stat	-0.8423253	
P(T<=t) one-tail	0.20601019	
t Critical one-tail	1.74588422	
P(T<=t) two-tail	0.41202039	
t Critical two-tail	2.11990482	

Table 16 shows the results of the unpaired t-test analysis of the ABO score at the time of debond, one year into retention, and the changes observed between these times for the Hawley and Circumferential groups.

Table 17. STATISTICAL ANALYSIS OF CERTAIN ABO CRITERIA AS APPLIED TO HAWLEY AND CIRCUMFERENTIAL GROUPS.

Change in Marginal Ridge

t-Test: Two-Sample Assuming Equal Variances

	H Appliance	*C Appliance*
Mean	-1.6363636	-0.2857143
Variance	7.05454545	4.57142857
Observations	11	7
Pooled Variance	6.12337662	
Hypothesized Mean Difference	0	
df	16	
t Stat	-1.128902	
P(T<=t) one-tail	0.13779085	
t Critical one-tail	1.74588422	
P(T<=t) two-tail	0.27558171	
t Critical two-tail	2.11990482	

Change in Occlusal Contacts

t-Test: Two-Sample Assuming Equal Variances

	H Appliance	*C Appliance*
Mean	-1.1818182	-0.7142857
Variance	27.1636364	2.9047619
Observations	11	7
Pooled Variance	18.0665584	
Hypothesized Mean Difference	0	
df	16	
t Stat	-0.2275009	
P(T<=t) one-tail	0.41145791	
t Critical one-tail	1.74588422	
P(T<=t) two-tail	0.82291583	
t Critical two-tail	2.11990482	

Change in Buccal/ Lingual Inclination

t-Test: Two-Sample Assuming Equal Variances

	H Appliance	*C Appliance*
Mean	-0.4545455	1.28571429
Variance	6.27272727	2.23809524
Observations	11	7
Pooled Variance	4.75974026	
Hypothesized Mean Difference	0	
df	16	
t Stat	-1.649801	
P(T<=t) one-tail	0.05923721	
t Critical one-tail	1.74588422	
P(T<=t) two-tail	0.11847441	
t Critical two-tail	2.11990482	

Table 17 shows the results of the unpaired t-test analysis of the changes in certain ABO criteria from the time of debond to, one year into retention between the Hawley and Circumferential groups.

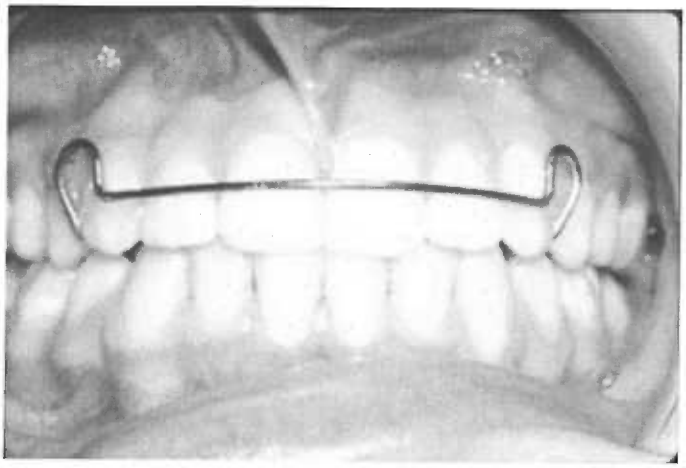

Fig. 1 Frontal view of Hawley retainer

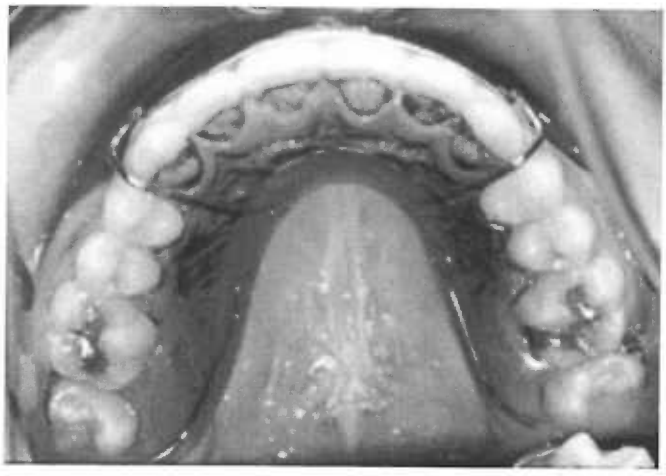

Fig. 2 Occlusal view of Hawley retainer

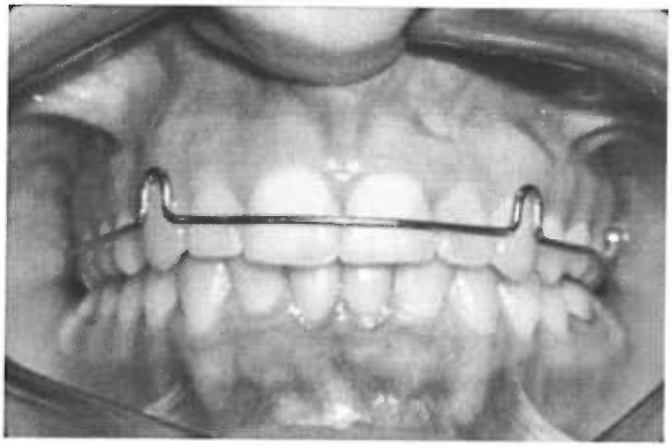

Fig. 3 Frontal view of circumferential retainer

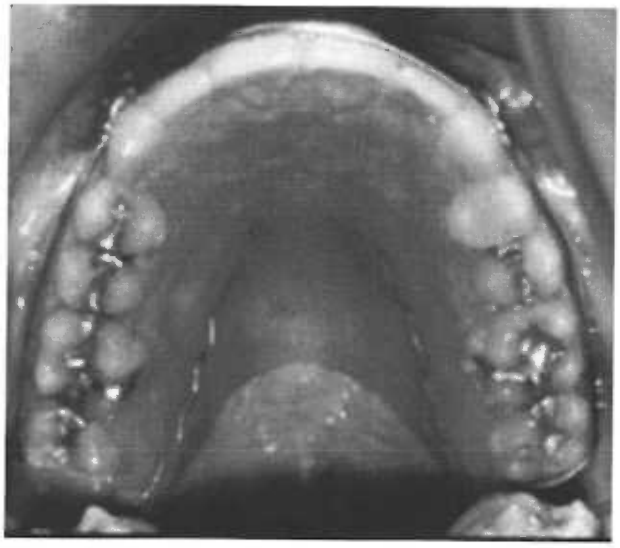

Fig. 4 Occlusal view of circumferential retainer

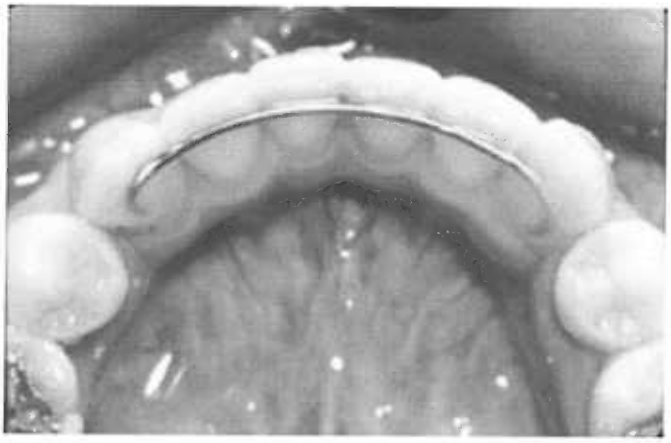

Fig. 5 Lingual view of mandibular bonded canine to canine retainer

Bibliography

1. Artun J, Spadafora A, & Shapiro P. A 3-year follow-up study of various types of orthodontic canine-to-canine retainers. Europ J of Orthod 1997; 19:501-509

2. Berry D.C., Singh B.P. Daily variation in occlusal contacts. J of Pros Dent 1983; 50(3):386-391.

3. Blake M, Garvey M, Rationale for retention following orthodontic treatment. J Can Dent Assoc 1998; 64(9):640-643.

4. Collett T. A rationale for removable retainers. JCO 1998; XXXII (11):667-669

5. Dahan J. Occlusal and functional evaluations in adults: A case report. Am J Orthod 1998; 114:551-557.

6. Durbin D, Sadowsky C. Changes in occlusal contacts following orthodontic treatment. Am J Orthod 1986; 90(5):375-381

7. Gazit E, Lieberman M. Occlusal contacts following orthodontic treatment measured by the photocclusion method. Angle Orthod 1985; 55 (4): 316-320.

8. Haydar B, Ciger S, Saaçi P. Occlusal contact changes after the active phase of orthodontic treatment. Am J Orthod 1992; 102(1): 22-28.

9. Josell S. Tooth stabilization for orthodontic retention. Dent Clinics of N Amer 1999; 43(1): 151-164.

10. Laidlaw (Guyette) Andrea. Comparison of Post-Treatment Occlusal Settling Utilizing Hawley Versus Circumferential Maxillary Retainers. Certificate Graduate Research Project, Oregon Health Sciences University, Portland, June 12, 2000.

11. Lindauer S, Shoff R. Comparison of Essix and Hawley etainers. JCO 1998; 32 (2): 95-98

12. Linder JP. Centric occlusion contacts in subjects with Angle's class I and class II molar relationships. MS Thesis, Marquette University, Milwaukee, 1973.

13. Little R. Stability and relapse of dental arch alignment, Ch6. Retention and Stability in Orthodontics. Nanda, RS & Burstone, CJ. (9th ed), W.B. Saunders Co. Philadelphia. 1993. Pp 97-113.

14. Little R. Stability and relapse of mandibular anterior alignment. AM J Orthod 1981;80:349-365.

15. Mamandras A, Foley T. Orthodontic retention. J Can Dent Assoc 1996; 62(5):412-417.

16. Melrose C, Millett D. Toward a perspective on orthodontic retention? Am J Orthod 1998; 113(5):507-514.

17. Nanda RS, Zernick J. Retention and Stability an Overview, Prologue . Retention and Stability in Orthodontics. Nanda RS, Burstone, CJ (9thed), W. B. Saunders Co. Philadelphia. 1993. pp 1-9.

18. Oppenheim A. Int J Orthod 1934; vol6: June.

19. Razdolsky Y, Sadowsky C, BeGole E. Occlusal contacts following orthodontic treatment: a follow-up study. Angle Orthod 1988; 59(3):181-186

20. Reitan K. Principles of retention and avoidance of post-treatment relapse. Am J Orthod 1969; 55(6): 776-790.

21. Richardson E, Margaret. A review of Changes in Lower Arch Alignment From Seven to Fifty Years. Seminars in Orthodontics 1999; Vol 5, No 3: 151-159.

22. Rossouw P, Emilie. Terminology: Semantics of Postorthodontic Treatment Changes in the Dentition. Seminars in Orthodontics 1999; Vol 5, No 3: 138-141.

23. Sadowsky C, Sakols E. Long-term assessment of orthodontic relapse. Am J Orthod 1982; 82(6):456-463.

24. Sauget E, Covell D, Boero R, Lieber W. Comparison of occlusal contacts with use of Hawley and clear overlay retainers. Angle Orthod 1997; 67(3):223-230.

25. Shapiro PA, Kokich VG. The rationale for various modes of retention. Dent Clin North Am 1981; 25:177-192.

26. Tibbetts. The effectiveness of three orthodontic retention systems: a short-term clinical study. Am J Orthod 1991;106(6): 671.

27. Vaden J, Harris E, Zeigler Gardner R. Relapse revisited. Am J Orthod 1997; 111(5):543-553.

28. Weinberger BW. Orthodontics: A historical review of its origins and evolution. Vol I & II. The Mosby Co. St. Louis, 1926.

29. Yen Edwin. Stability of Orthodontic Treatment: Myth or Reality. A peak at the Future. Seminars in Orthodontics 1999; vol5, No3: 205-206.

30. Zachrisson B. Important aspects of long-term stability. JCO 1997; XXXI(9(:562-581.

31. Ziebert G, Donegan S. Tooth contacts and stability before and after occlusal adjustment. J of Pros Dent 1979: 42(3):276-281.