Retrospective evaluation of A Modified Bonded Lingual Retainer for the Maxillary Incisors

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Abstract:

Prevention of tooth relapse after orthodontic tooth alignment has been one of the greatest challenges within the field of orthodontics. Studies have found that following orthodontic treatment, it is not possible to accurately predict which patients will relapse and to what extent. Removable retainers rely on patient compliance to wear them continuously so teeth are held in place. The development and use of fixed retention takes away the need for patient compliance. The purpose for this study was to see if there is a difference in how an upper Hawley retainer and a fixed lingual retainer bonded to the upper central and lateral incisors hold teeth in place. Another purpose was to see if there are any differences in periodontal charting measurements between the two groups as the fixed retainer may interfere with oral hygiene. A random chart review from a private orthodontic practice and the OHSU orthodontic clinic was done to identify potential participants. Each group consisted of 25 subjects and had similar means for initial irregularity (9.0, Little's Index) and similar means for time in retention (41.8 months). To qualify, subjects had to be in retention for at least seven months and have before and after treatment dental study models available. Qualifying subjects were called by phone and asked to participate in this study. Each subject had a photograph and impression taken of their upper front six teeth. Little's index of irregularity was used to calculate tooth irregularity from the upper right canine to the upper left canine. Periodontal measurements (probing depths, bleeding on probing, gingival recession) around the upper incisors were measured with a periodontal probe. T-tests were run to evaluate if there was a difference between groups in how well the teeth have been held in place and for periodontal recordings. Regression analysis was done to see if there were relationships

between time in retention and amount of relapse, initial irregularity and relapse, bleeding sites around the canines and bleeding sites around the central and lateral incisors, time in retention and number of bleeding sites, age and number of bleeding sites, time in retention and probing depths, age and probing depths. The acceptable *P*-value was set at 0.05 for all variables.

(1.) No significant difference could be found for retention times or initial irregularity between the two groups. (2.) A significant difference was found between the Hawley and bonded groups for relapse. (3.) There was no significant relationship for time in retention and amount of relapse for the Hawley group or the bonded group. (4.) There was no significant relationship for initial irregularity and relapse. (5.) There was a significant difference in the number of bleeding points between the Hawley and the bonded groups. (6.) For the Hawley group, there was a significant positive relationship for bleeding on the canines and bleeding on the central and lateral incisors but not for the bonded group. (7.) There was no significant relationship for age and number of bleeding points, number of pockets and time in retention, age and number of pockets. (8.) No significant differences were found for the number of pockets (3.5 and above), recession or age between the two groups. (9.) There was no evidence to show that the bonded maxillary retainer contributes to periodontal disease. (10.) The bonded maxillary retainer appears to be a good retainer to keep upper incisors in good alignment for many years.

Introduction:

Relapse following orthodontic treatment posses a dilemma for orthodontists and their patients. It is not possible to predict who will have dental alignment relapse and to what extent. For over 35 years, orthodontists at the University of Washington have studied a growing collection of over 600 sets of patient records to assess the stability of orthodontic treatment (Little, et al 1981, Sinclair & Little 1983, Shields, et al 1985, Sinclair & Little 1985, Little, et al 1988, Little & Riedel 1989, 1990, Little, et al 1990, McReynolds & Little 1990). All patients completed treatment a decade or more prior to the last set of posttreatment records. Evaluation of treated premolar extraction cases, treated non-extraction cases with generalized spacing, cases treated by arch enlargement strategies, and untreated normal occlusions demonstrated similar physiological changes. It was found that arch length decreases over time following orthodontic treatment, as well as in untreated normal occlusions. Arch width measured across the mandibular canine teeth typically reduces posttreatment whether the case was expanded during treatment or not, and mandibular anterior crowding during the posttreatment phase continues well into the 20-40 age bracket and beyond. The degree of post-retention anterior crowding is both unpredictable and variable, with no pretreatment variables proving to be useful predictors either from clinical findings, casts, or cephalometric radiographs before or after treatment proving to be useful predictors.

Studies such as these and the clinical observations of private practitioners have lead to the development of various forms of fixed permanent or semi-permanent retention. Use of fixed retention is becoming more and more popular (Wong 2004). The idea behind fixed retention is that it takes away the need for patient compliance because it

is bonded in place. However, because fixed retainers cannot be removed by the patient before routine brushing or flossing like removable retainers, there may be an oral hygiene concern. It would be interesting to know if there is a relationship between bonded retainers and compromised periodontal health. By comparing the number of bleeding sites, probing depths and gingival recession between a bonded retainer group and a removable Hawley retainer group (as a control), it may be possible to see if there is a difference between the two groups.

Literature Review:

At the completion of orthodontic treatment, retention is a requirement to help ensure that teeth stay in position. Currently all orthodontists provide their patient with some form of retention at the completion of treatment. Retention protocols differ significantly from practitioner to practitioner. A popular combination is a removable upper retainer with a lower bonded 3-3 retainer (Sheridan 2004, Wong 2004).

A variety of removable retainers are currently in use such as the Hawley retainer, the wrap-around retainer, the clear vacuum form retainer and modified versions of these retainers. The Hawley retainer has been the most frequently used of the removable retainers (Kahl-Nieke 1996, Mamandras 1996). Removable retainers are only effective if the patient is diligent enough to wear them and does not lose or break them.

Historically, clinicians have not agreed on the need for retention due to lack of knowledge on what causes relapse. Many theories have been developed as to what will maintain tooth alignment. It was thought if perfect tooth alignment was achieved, teeth

would be stable when fixed appliances were removed. Time has proved that this theory, like many others is untrue (Nett 2005).

Different schools of thought have developed which claimed to know the key to stability. For example, the occlusion school (Kingsley 1880) believes that a balanced occlusion is the most important factor, the apical base school (Lundstrom 1925) states that the apical base position is the most important factor, the mandibular incisor school (Tweed 1944, 1952) states that the mandibular incisors must be kept upright and be over basal bone and the musculature school (Rogers 1922) necessitates the need to establish a proper and functional muscle balance in order to establish stability. Although contemporary concepts combine several of these ideas, there is still no consensus and there is still no ideal treatment plan, no specific set of orthodontic mechanics or end of treatment outcome which can guarantee freedom from relapse. (Graber 2005, p.1124)

Another theory is that the PDL needs enough time to remodel in order for the tooth to remain stable. Reorganization of the periodontal ligament occurs over a three to four month period after treatment (Reitan 1967, 1969), whereas the gingival collagen-fiber network takes about four to six months to remodel and the elastic supracrestal fibers remain deviated for more than 232 days (Reitan 1967). However, even after being in retention for several years, when retainers are removed, there is a great chance that some relapse will ensue (Little 1990).

Edwards developed techniques to detach the supracrestal fibers of the PDL from its environment, relieving the elastic tension of the fibers that would cause teeth to relapse toward their original positions. However, studies have shown that this reduces rotational relapse by an average of only 30 percent (Edwards 1988).

After much trial and error, new ideas and failed strategies and of course the passage of time, teeth continued to relapse. Thus the idea of permanent or semi-permanent retention has more recently become a very popular concept (Wong 2004). Fixed retention eliminates the need for patient compliance. Due to the popularity of the lower bonded 3-3 retainer, there have been many publications concerning their use in long term retention (Zachrisson 1995, Artun 1997, Durbin 2001). In general, it has been found that this device keeps the teeth well aligned, has a low breakage rate, does not harm the periodontium, does not increase the rate of caries and is well accepted by patients (Bearn, 1995, Cerney 2001).

Dahl and Zachrisson (1991) studied two groups of bonded retainer subjects, one with three-stranded spiral wire (3SW) and one with five-stranded spiral wire (5SW). The 3SW group consisted of 41 subjects with retainers on the maxilla only, 14 with mandibular retainers only and 15 with bonded retainers on both arches. The 5SW group consisted of 55 subjects with maxillary retainers only, eight in the mandible only and nine in both arches. The 3SW group was in retention for about six years and the 5SW group was in retention for about three years. In four 3SW patients, they found small spaces of about .5mm open up among the central or lateral incisors within the retained segments with no loosening of the retainers.

Dahl and Zachrisson (1991) also found that with retainers bonded to two or three teeth in patients who had median diastemas before treatment, slight re-rotations of one or both maxillary central incisors was observed. Irregularity did not increase within any intact retainer, either in the maxilla or in the mandible. Inadequate hygiene with bleeding upon probing was observed in seven patients. Deposits of plaque and calculus along the

maxillary retainer wires were rare. Accumulation of plaque and calculus was more common among the mandibular retainers, but only in one case was it considered necessary to refer the patient for calculus removal. There were no signs of dental caries or carious white spot lesions in any patients.

Heier (1997) did a study to evaluate whether differences in gingival conditions or build-up of plaque and calculus existed between patients who wear removable versus fixed retainers. No differentiation was mentioned about upper versus lower bonded retainers. Maxillary and mandibular measurements were taken just before debonding and at one, three and six months later, from canine to canine on 36 patients. Among these patients, 22 had fixed retainers and 14 wore removable retainers. Gingival inflammation decreased from baseline throughout the entire period of retention. A comparable limited gingival inflammation was found in the presence of both types of retainers. Slightly more plaque and calculus were present on the lingual surfaces in the fixed retainer group. This did not result in more pronounced gingival inflammation than in the removable retainer group, within the evaluated period.

A long-term study was done by Robert Cerny (2001) on permanent upper and lower fixed lingual retainers. His study involved a survey of 350 patients treated in his practice over a 17 year period. Most patients were in retention for two to five years and the range was one to17 years in retention. He found that the overall effectiveness of the fixed lingual retainer was excellent. It held the bonded teeth securely in place. The teeth distal to the retainer occasionally showed rotations or spacing from labial or lingual movement. There was no significant increase in caries or periodontal disease that could be attributed to the bonded retainers. Some patients had lower anterior calculus build up

that required removal. There was no mention of finding calculus on maxillary bonded retainers. Independent assessments by general dentists of some of the long-term fixed lingual retention patients found no damage to the dental tissues.

To find out if fixed or removable mandibular retainers caused any damage to the teeth or periodontal tissues, Artun (1986) placed 44 patients into four groups; (1.) thick plain wire bonded only to canines, (2.) thick spiral wire bonded only to canines, (3.) thin flexible spiral wire bonded to each tooth in segment, and (4.) a removable retainer group. Accumulation of plaque and calculus along the gingival margin and gingival inflammation were scored in lingual areas from canine to canine, at time of fixed appliance removal and again four months after retainer insertion. In addition, accumulation of plaque and calculus and development of caries along the retainer wires were scored after four months. The results revealed no differences between the groups for any of the variables. No differences in accumulation of plaque was found between baseline and follow-up examinations. Gingival bleeding was scored less frequently after four months in retention than at the time of debonding (Artun 1986).

There has been a relative lack of published reports on fixed retention of the maxilla. This may because it is used less frequently than mandibular lingual fixed retention (Wong 2004). However, the changes which occur on the mandibular arch occur in the maxillary arch as well, even if it is to a lesser extent on average (Little 1990). The alignment of the maxillary incisors is the most noticeable esthetically, so ensuring that those teeth stay aligned is important.

If a well designed fixed maxillary retainer can be made, it would seem wise to utilize it in order to reduce the incidence of relapse in the maxillary arch and reduce the

need for re-treatment. A good retainer must posses certain characteristics. It should stabilize the teeth in the desired position, permit the forces associated with physiologic functional activity to act freely on the retained teeth, it should be reasonably easy to clean, relatively easy to make, last a long period of time without breaking or deforming, it should not harm the periodontal health of oral tissues, it should be esthetic and it should be comfortable and acceptable to the patient (Mayne 1972, Sperry 1982).

Several types of maxillary 2-2 and 3-3 bonded retainers have been developed and put into use. However, most are lacking in one or more of the above criteria which defines a good retainer. Below are several examples.

- An early design of a bonded maxillary 3-3 retainer was made out of .030 or .036 round stainless steel wire which was directly bonded to the facial surface of the cuspids (Rubenstein, 1976). However, this retainer is very unesthetic and there has been no studies on its long term use.

- Staples have been used to hold teeth together which had diastemas pretreatment. This method requires the use of anesthetic to prep teeth inside the marginal ridge and use a drill to make a hole two millimeters in depth. .024 SS wire is bent into a staple shape and placed in the two holes, then cemented in place with restorative material. An advantage is that this appliance is easy to construct, and is esthetic but requires the use of anesthetic and the sacrificing of tooth structure. Also, according to Chan, the staples may not last as long as other types of permanent retainers and it is "doubtful" and unproven that the retainer would last for a 10 to 20 year time period (Chan 1975).

- A bonded lingual 3-3 maxillary retainer can be made with a straight segment of .015-.020 SS multistrand wire bonded to each tooth in the segment (Zachrisson 1985). A disadvantage to this design is that it requires the use of a floss threader when cleaning and the short span of wire between the teeth will increase the likelihood of fractures.

- Another type of fixed maxillary 3-3 retainer is made from .018 Wilcock wire and has loops between all teeth which allows for flossing without a floss threader. It also allows the interproximal spaces to be cleaned more easily at dental hygiene visits and interproximal dental restorations can be done if need. The length of the wire is increased between teeth providing flexibility which allows for more physiologic tooth movement and fewer bond failures. The loops also help to prevent relapse of root torque (Cerney 2001). A major disadvantage to this retainer is that it is time consuming to bend.

-Sperry (1982) uses a U-shape design to hold diastemas closed between upper central incisors. His loops are large and sit centered between the marginal ridges. He also uses a relatively thin wire (.014 stainless steel) (Sperry 1982). No studies were published on this specific design.

The present study will evaluate a modified design of a maxillary bonded 2-2 retainer which is constructed from a .024 stainless steel round wire. It consists of 3 pieces of wire, which are bent into a U-shape (see Figure 1). After 2002, teardrop loops were added onto the ends (see Figure 2). These loops are bonded onto the teeth, with the bottom of the U facing palatally, and the loops or ends pointing incisally, sitting below the occlusion, and mesial to the marginal ridges.

Figure 1. An example of a bonded retainer without teardrop loops

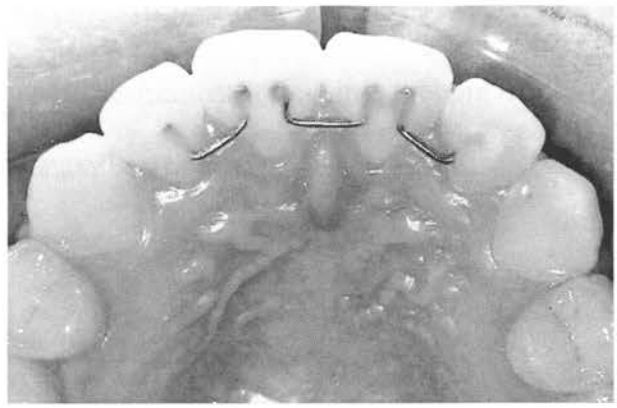

Figure 2. An example of a bonded retainer with teardrop loops

There have been no published reports on this fixed maxillary retainer. To quantify how well this retainer holds teeth in position would be beneficial to practitioners and patients alike. It is also important to analyze if this retainer will contribute to periodontal disease. If this retainer proves to retain teeth well and does not contribute to periodontal disease, it may be a very useful fixed retainer.

The purpose of this study was to measure the long-term effectiveness in maxillary incisor alignment of a modified maxillary bonded 2-2 (lateral incisor to lateral incisor) fixed retainer compared to a maxillary removable Hawley retainer.

Little's Index (Little 1975) is commonly used to measure incisor alignment or irregularity because it is a simple and quantitative method. The teeth are measured parallel to the occlusal plane. The linear displacement of the five adjacent anatomic contact points of the incisors is measured and added up. Since we would like to observe how well a bonded 2-2 lingual retainer can hold the upper incisors in place, we decided to apply Little's index, (which is normally used to measure the irregularity of the lower incisors) to the upper incisors in the same fashion (See Figure 4).

Another purpose of this study was to measure if there was any difference in periodontal measurements (bleeding, probing depths and recession) in subjects with a modified maxillary bonded 2-2 retainer compared to subjects with a maxillary removable Hawley retainer.

It was hypothesized that patients with the bonded maxillary retainer will have teeth which are retained in better alignment than patients that were given a removable Hawley retainer and that both groups will have similar periodontal charting measurements (bleeding, probing depths and gingival recession.)

Materials and Methods :

Internal review board approval was obtained for the study. Subjects for this study consisted of two groups of 25. The bonded lingual 2-2 retainer sample was from a private orthodontic office in Honolulu, Hawaii (Stanley Masaki D.D.S.). The removable upper Hawley (3-3) retainer sample was from the orthodontic clinic at the Oregon Health and Science University in Portland, Oregon. All subjects had to have been in retention

for at least seven months and had before treatment and after treatment (at debonding) dental casts available.

For each group, a random chart review was done to find potential participants who were given the specified type of retainer at the end of orthodontic treatment. Potential subjects were contacted by phone and asked to come in for a retention check, informed of the study and given the opportunity to participate. Each subject received a formal informed consent at the office visit. For the bonded retainer group, the first 25 subjects that agreed to participate and who could come in during a specified data collection week while the investigator was in Hawaii were used. (Eight subjects had the bonded retainer without teardrop loops, 17 subjects had the bonded retainer with teardrop loops.)

The Hawley retainer group was matched to the bonded retainer group so that the time in retention and the amount of initial irregularity of the two groups would have similar means and standard deviations.

Each participating subject was assigned a number which was used instead of the patients name on all records collected and used for the study in order to maintain patient confidentiality. The investigator examined the subjects in a standard dental chair, using a light. An alginate impression and photo of the upper six front teeth were taken. At the completion of the exam, subjects were given $40.00 as an inducement to participate.

Inclusion criteria:

1. Before and after treatment models available
2. In retention for at least seven months

3. Able to come in for a recall appointment during specified time period

Exclusion criteria:

1. peg laterals
2. congenitally missing upper incisor(s)
3. dental restorations placed on upper incisors after completion of orthodontic treatment

Measuring relapse

To determine the effectiveness of retention of the fixed maxillary retainer and Hawley removable retainer, tooth alignment and irregularity were measured on the models from pretreatment (T1), end of treatment (at the time of debonding: T2) and retention recall appointment (T3). Occlusal views of the maxillary casts were scanned into a computer and printed (see Figure 3). A ruler was scanned in at the same time to check for distortion. The ruler was checked with a digital caliper to make sure both had the same readings. The digital caliper was then used to calculate Little's index of irregularity (Little 1975) from the print out (to the nearest hundredth.) The difference in scores from T2 to T3 represent the amount of tooth relapse which had taken place. The operator error of Little's Index (see Figure 4) was done by randomly selecting ten casts (five from each group) and measuring them again three weeks later for the three time points (T1, T2, T3). The Dahlberg's statistic was used $S = \sqrt{\sum (d^2 /2n)}$ (Dahlberg, 1940), where d is the difference between the first and second measurements and n is the number of determinations (in this case 30.) The precision for the Index (sum of five measurements) was high with a mean of less than 0.5 mm.

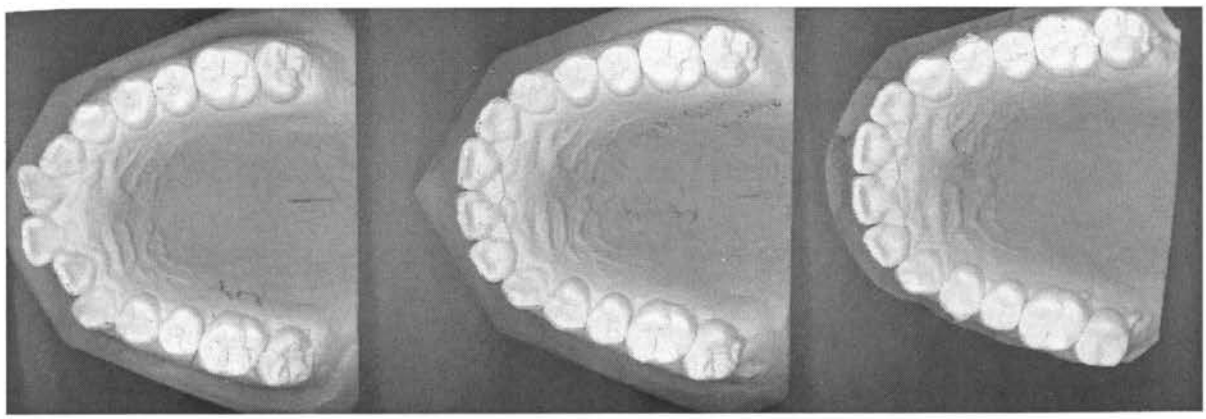

Figure 3. Scanned images of the models at (left to right) T1, T2 and T3.

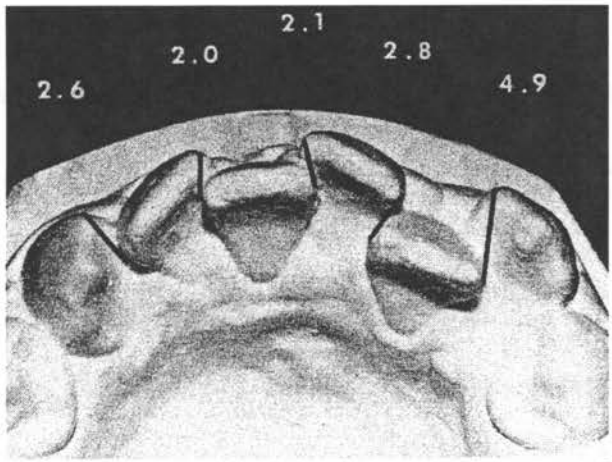

Figure 4. Example of the five measurements of Little's Index (Little, 1975).

Measuring periodontal health

To determine if there is observable periodontal consequences of the fixed retainer and the removable retainer periodontal measurements were compared. (1.) Periodontal probing depths (the distance to the nearest half millimeter from the gingival margin to the base of the crevice), were recorded. (2.) For gingival recession (from the cemento-enamel junction to the gingival margin, nearest 0.5mm) the longest measurement per tooth surface 'buccal or lingual' was recorded. (3.) Bleeding (present or not present) was also recorded. All measurements were taken from the maxillary right canine to the

maxillary left canine on each subject. Measurements were taken at six places around each tooth, at the distal, middle and mesial on both the facial and palatal surfaces using a PCPUNC126 periodontal probe by Hu-Friedy (1 mm increments.)

Statistics:

Stata data analysis and statistical software was used. Levene's test for equality of variance was performed to determine if equal variances could be assumed. Two-sample t-test using equal variances were used for time in retention, initial irregularity, pocket depth, recession and age. Unequal variances were used for bleeding points and relapse. Two-sample t-tests were used to evaluate if there was a significant difference between the two groups for time in retention, initial irregularity, relapse, number of pockets (3.5 and above), bleeding points, recession and age.

Regression analysis was performed for (1) retention time and relapse, (2) initial irregularity and relapse, (3) number of bleeding points for the upper canines and number of bleeding points for the upper centrals and lateral incisors, (4) retention time and number of bleeding points, (5) age and number of bleeding points, (6) retention time and pockets, and (7) age and pockets were performed. The acceptable statistical significance level was set at $P \leq 0.05$ for all tests.

Results:

No significant difference could be found for retention times between the two groups ($P > 0.05$). The mean time in retention for the Hawley group was 39.92 months, SD 44.5 and for the Bonded group 43.76 months, SD 46.55. (see Figure 5)

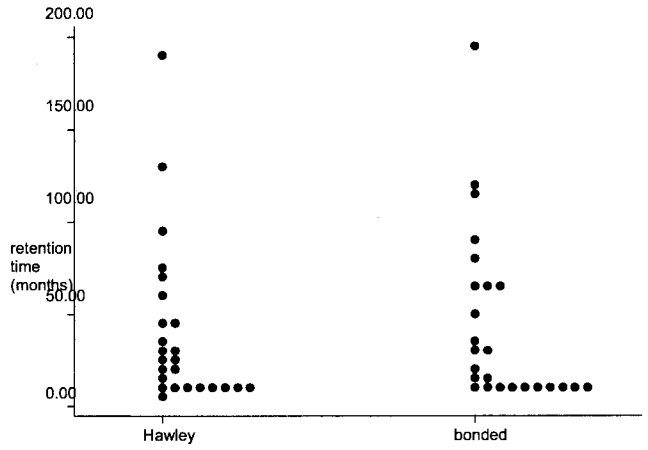

Figure 5. Retention time in months for the Hawley subjects and the bonded subjects. There is no significant difference for time in retention between the two groups.

No significant difference was found between initial irregularity between the two groups ($P > 0.05$). The mean for the Hawley group was 8.29, SD 3.27 and 9.70, SD 3.58 for the bonded group. (see Figure 6)

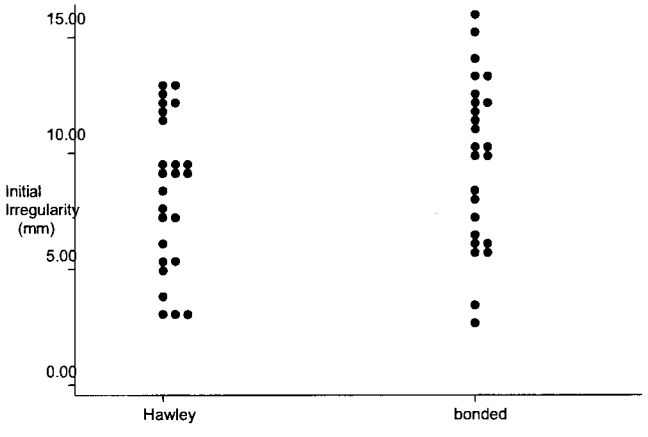

Figure 6. Amount of initial irregularity present in the Hawley subjects and the bonded subjects. Neither mean nor variability of initial irregularity is significantly different between the two groups.

A significant difference for differences in relapse between the two groups was found ($P<0.05$). The mean relapse for the Hawley group was 0.83, SD 1.205. The mean relapse for the bonded group was 0.084, SD 2.88 (see Figure 7). It was found that the

mean and variability of relapse was significantly different between the groups. (see Figure 7)

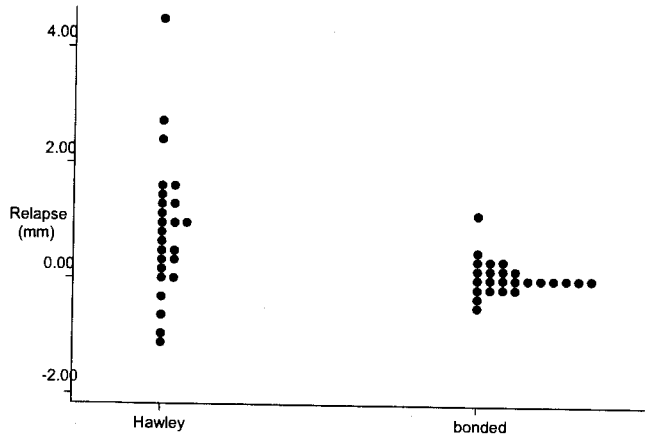

Figure 7. Amount of relapse present in the Hawley subjects and the Bonded subjects. Both the mean and variability of relapse are significantly different.

There was no significant relationship for time in retention and amount of relapse for the Hawley group or the bonded group (P>0.05). (see Figure 8)

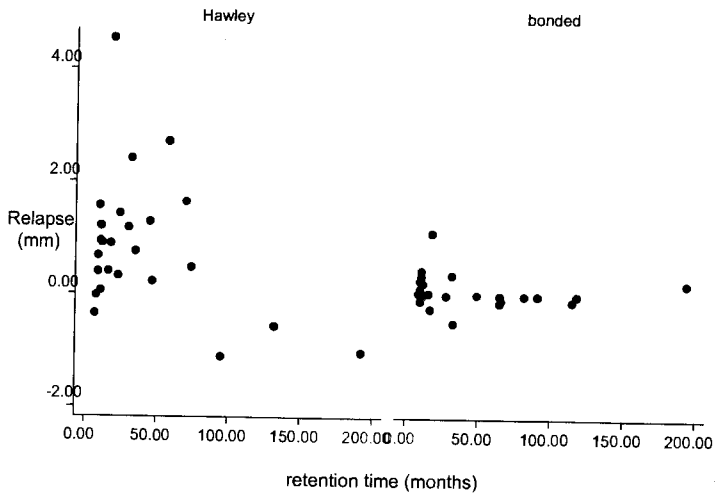

Figure 8. Time in retention and amount of relapse for the Hawley and bonded group.

Initial irregularity and amount of relapse. No significant relationship is found between initial irregularity and relapse (P>0.05). (see Figure 9)

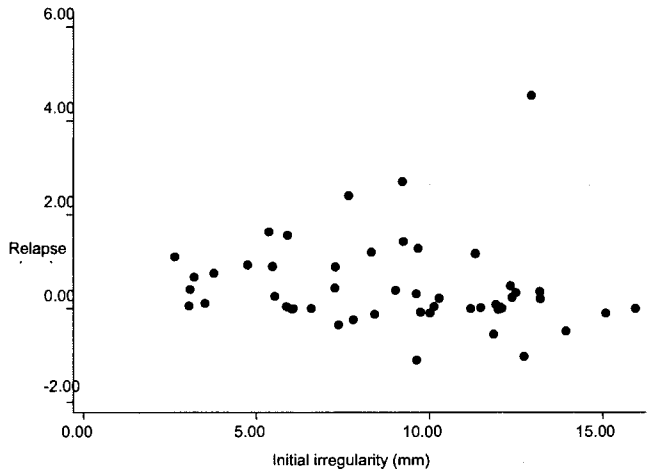

Figure 9. Initial irregularity and amount of relapse for Hawley and bonded retainer

There was a significant difference in the number of bleeding points between the two groups (P <0.05). The mean number of bleeding points for the Hawley group was 5.96, SD 7.3 and the mean number of bleeding points for the bonded group was 1.72, SD 1.24. (see Figure 10)

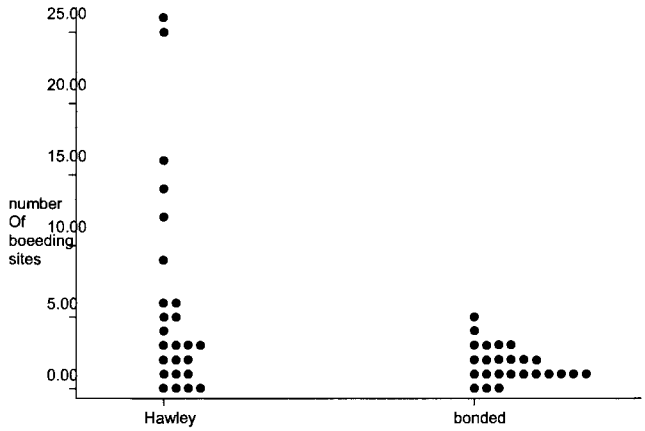

Fig 10. Number of bleeding points for the Hawley subjects and the bonded subjects. Both the mean and variability of bleeding seem to be significantly different depending on group.

For the Hawley group, there was a significant positive relationship for bleeding on the canines and bleeding on the central and lateral incisors ($P<0.05$). There was no significant relationship for bleeding on the canines and bleeding on the central and lateral incisors for the bonded group ($P>0.05$). (see Figure 11)

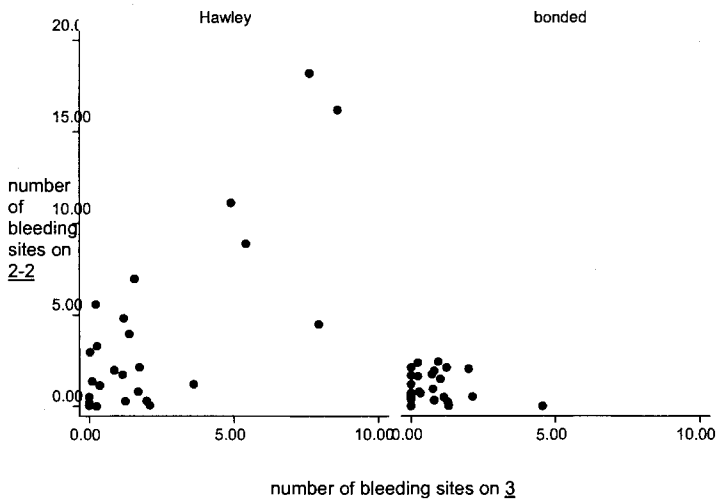

Figure 11. Relationship of bleeding on the canines and bleeding on the central and lateral incisors for the Hawley and bonded groups.

There is no significant relationship found between time in retention and amount of bleeding present ($P>0.05$). (see Figure 12)

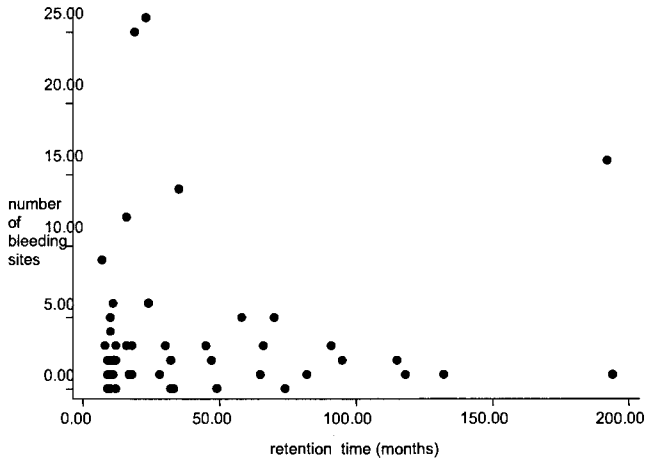

Figure 12. Relationship between time in retention and number of bleeding points.

There is no significant relationship for age and number of bleeding points (P>0.05). (see Figure 13)

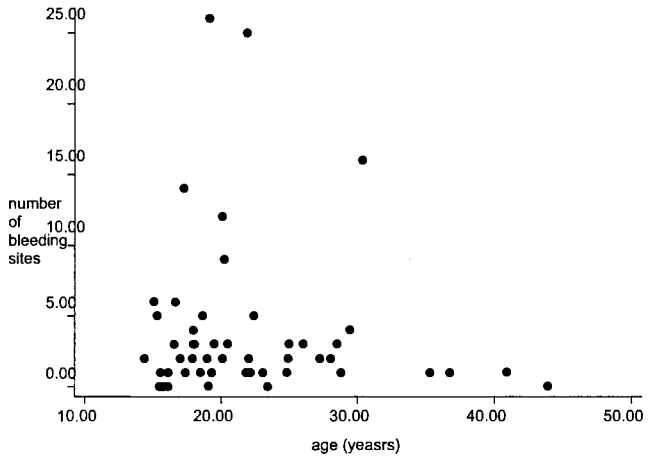

Figure 13. Relationship for age and number of bleeding points.

No significant differences were found for the number of pockets (3.5 and above) between the two groups (P > 0.05). The mean number of pockets was 1.44, SD 2.97 for the Hawley group and .6, SD 1.68 for the bonded group. (see Figure 14)

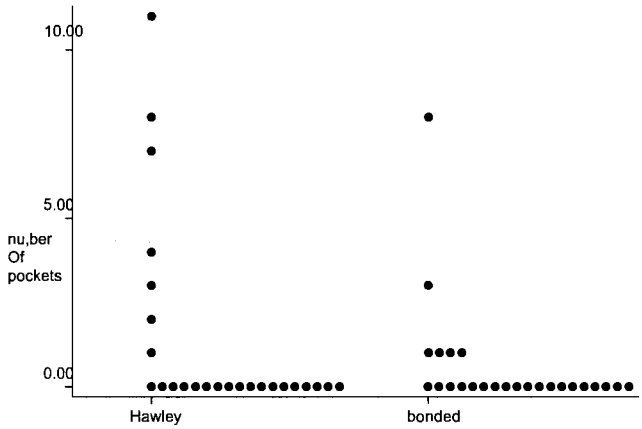

Figure 14. Pockets present in the Hawley subjects and the bonded subjects. Pockets present in the Hawley subjects and the bonded subjects. The number of pockets is not significantly different between the two groups.

There is no significant relationship for number of pockets and time in retention (P>0.05). (see Figure 15)

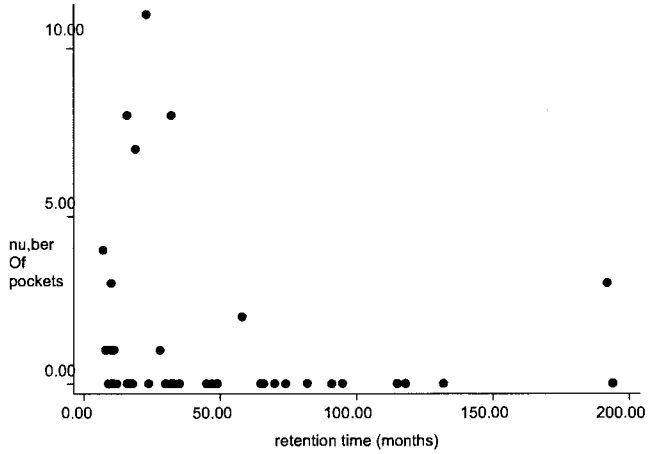

Figure 15. Relationship for number of pockets and time in retention.

There is no significant relationship for age and number of pockets ($P>0.05$). (see Figure 16)

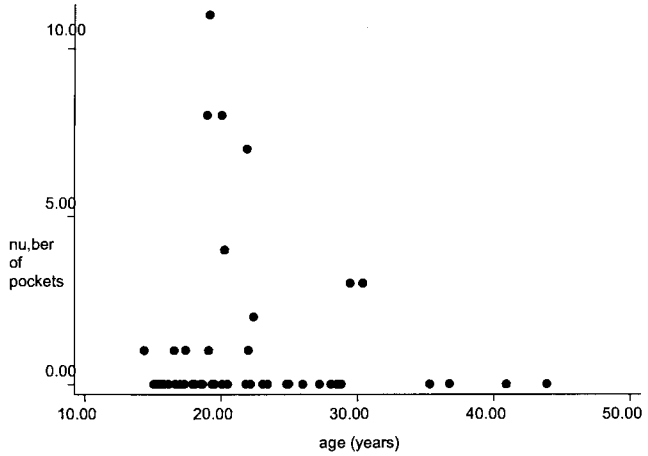

Figure 16. Relationship for age and number of pockets.

No difference for recession was found between the two groups ($P>0.05$). Only two subjects in the Hawley group presented with recession two subjects on the bonded group presented with recession. (see Figure 17)

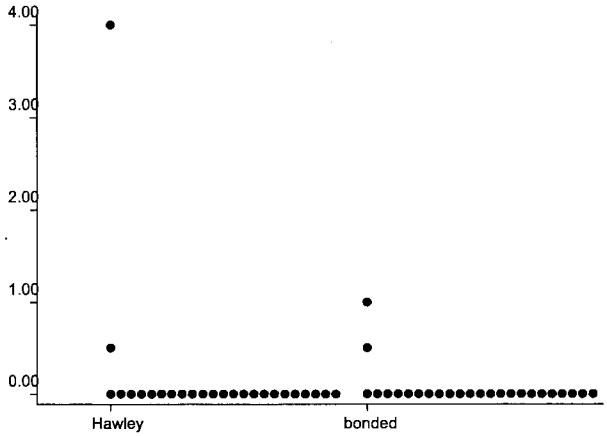

Figure 17. Amount of recession present in the Hawley subjects and the bonded subjects. Recession is not significantly different between the two groups.

There was no significant difference in age between the two groups ($P>0.05$). The mean for the Hawley group was 21.13, SD 6.4 and 22.79, SD 7.0 for the bonded group. (see Figure 18)

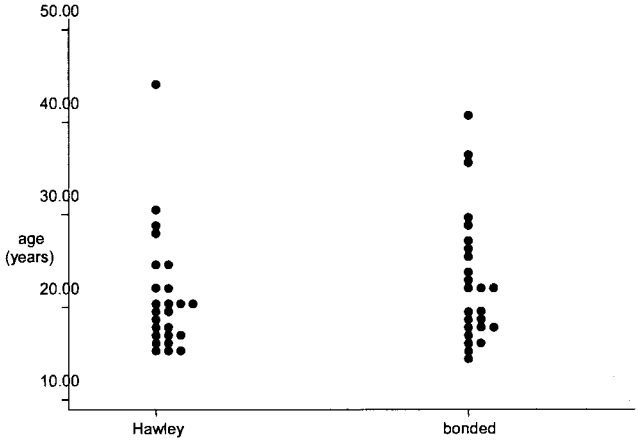

Figure 18. Ages of the Hawley subjects and the bonded subjects. The mean age of the two groups is not significantly different.

Data Tables:

Table I. Summary of Variable Means

	Time in retention (months)	Initial irregularity (mm)	Relapse T3-T2 (mm)	Number of bleeding sites	Number of pockets (3.5 and above)	Recession (mm)	Age (years)
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Hawley group range	**40.0** ± 44.5 7.0-192	**8.3** ± 3.2 3.0-12.9	**0.8** ± 1.2 0.4-4.7	**6.0** ± 7.3 0-26	**1.4** ± 3.0 0-11	**0.2** ± 0.8 0-4	**21.1** ± 6.4 15.1-43.9
Bonded group range	**43.8** ± 46.5 9-194	**9.7** ± 3.6 2.6-15.9	**0.1** ± 0.3 -0.5-1.1	**1.7** ± 1.2 0-5	**0.6** ± 1.7 0-8	**0.1** ± 0.2 0-1	**22.8** ± 7.0 14.4-40.9
Significantly different	no	no	***yes**	***yes**	no	no	no
Calculated *P*-value	0.77	0.15	< 0.01	< 0.01	0.22	0.47	0.39

P-value ≤ 0.05

Table II. Summary of Regression analyses performed

Regression analysis	Significant or not for a positive relationship	Calculated *P*-value
Relapse and retention time for Hawley group	no	0.06
Relapse and retention time for bonded group	no	0.50
Relapse and initial irregularity	no	0.33
Bleeding 2-2 and bleeding on 3 for Hawley group	***yes**	0.00
Bleeding 2-2 and bleeding on 3 for bonded group	no	0.36
Bleeding and retention time	no	0.94
Bleeding and age	no	0.61
Pockets and retention time	no	0.48
Pockets and age	no	0.68

P-value ≤ 0.05

Operator error:

Using the Dahlberg formula, it was found that the precision for the Index (sum of five measurements) was high with a mean of less than 0.5 mm.

Discussion:

This study shows that fixed retention can result in less tooth relapse. This coincides with the study done by Al Yami et al. (1999) who found that subjects who were given a fixed retainer over a removable retainer had 3.6 PAR points less at five years postretention and 4.6 points less at ten years. This study, like the studies of Heier (1997), Cerney (2001), and Artun (1986), does not find fixed retention to increase periodontal disease or attachment loss.

No overall correlations were found for initial irregularity and relapse, which coincides with Little's study (1990) where he found that anterior crowding is not a predictive variable for relapse. All of the Hawley subjects had their permanent canines erupted at T1. Three of the bonded subjects did not have one or both of their permanent canines in at T1. The overall irregularity of that group at T1 would likely be even greater if the canines were erupted. However, no relationship has been found for initial irregularity and tooth relapse in this study and others (Little, 1990).

The bonded group had significantly less relapse than the Hawley group. This would be expected since some Hawley patients were wearing their retainer and some were not. Some Hawley subjects also had broken or lost their retainer in the past, going for a varied time period without a retainer. Some of those subject had come back in for a new retainer and some did not. The bonded group all had their retainers present and intact. None of the bonded retainers were broken. There was no damage apparent to any of the bonded retainers. One subject previously had trauma to the mouth, causing one piece of his bonded retainer to become loose on one end. He came in for a repair before

any significant tooth movement could occur. The bonded retainer seems to have a good design which withstands time.

An overall correlation was found between time in retention and amount of relapse. When the groups were tested separately, there was a significant relationship in the Hawley group only. There was no significant relationship for time in retention and relapse for the bonded group. Previous studies have shown that with time, teeth continue to relapse, even after many years of retention (Little, et al 1981, Sinclair & Little 1983, Shields, et al 1985, Sinclair & Little 1985, Little, et al 1988, Little & Riedel 1989, 1990, Little, et al 1990, McReynolds & Little 1990.)

Although time in retention was calculated at the time of debond, some subjects were given temporary vacuum-form retainers for one to two months before receiving their Hawley retainer. It is unlikely that this would significantly affect the data because it is also a removable retainer which would require patient compliance to wear them.

At T3 some casts had a smaller irregularity than at T2. This may be due to teeth moving into better alignment after appliances were removed.

The bonded group had significantly less bleeding points compared to the Hawley group. This may be due to a difference in population groups; one from a private office which costs more, and one group from a university orthodontic clinic that has reduced fees. The cost difference may on average divide the groups into different social economic status (SES) groups. Lower SES has been correlated with poorer oral hygiene and more periodontal problems. Higher SES has been correlated with better oral hygiene and less periodontal problems (Sayegh et.al., 2002, Torrungruang 2005, Khader 2006, Lencova et. al. 2006).

If the Hawley retainer is not kept clean, calculus and plaque can form on it and potentially cause gingivitis. Color photos were taken of the bonded retainer and no calculus was seen visually on the retainer. This finding was similar to Dahl & Zachirisson (1991) where plaque and calculus deposits on the maxillary wire was rare. It was more common among the mandibular bonded retainers.

There were no significant differences for probing depths between groups. There were no overall correlations for age and number of bleeding points or age and probing depths. There were no overall correlations for time in retention and probing depths. This is likely because the incidence of gum disease and periodontal attachment loss increases with age (Albandar and Kingman 1999) and most of the subjects were young. The mean age of the Hawley patients was only 21.1, (range 16-44, SD 6.4 years) and 22.8, (range 17-41, SD 7.0 years) for the bonded group.

There was no significant difference for recession between the two groups. Two subjects in the Hawley group had recession. One had 0.5mm of recession on one tooth. The other had recession on three teeth measuring 1, 1.5 and 1.5mm. Two subjects on the bonded group had recession one with 0.5mm and the other with 1mm of recession. It is likely that this recession is not related to the retainer type because recession was found only on the facial aspect of the teeth.

There were some limitations to the study. The sample was from two different populations. Little's index of irregularity measures relapse from one perspective (occlusal) and only in one area of the dental arch. It would be interesting to compare these two groups using the PAR index or other indexes of alignment and occlusion. It would also be interesting for this study to be conducted from the same population from

the same orthodontic office. Many of the subjects had lower 3-3 bonded retainers. It would be interesting to conduct a study to see if there was a relationship of lower 3-3 alignment and upper incisor alignment. It would also be interesting to measure overbite changes at T1, T2 and T3 in both groups. Lastly, it would be ideal to have a randomized clinical trial rather than a retrospective study so that baseline periodontal measurements can be recorded and compared.

Summary/Conclusions:

1. No significant difference could be found for retention times between the two groups ($P > 0.05$). The mean time in retention for the Hawley group was 39.92 months, SD 44.5 and for the bonded group 43.76 months, SD 46.55.

2. No significant difference was found between initial irregularity between the two groups ($P > 0.05$). The mean for the Hawley group was 8.29, SD 3.27 and 9.70, SD 3.58 for the bonded group.

3. A significant difference in relapse between the two groups was found ($P < 0.05$). The mean relapse for the Hawley group was 0.83, SD 1.205. The mean relapse for the bonded group was 0.084, SD 2.88.

4. There was no significant relationship for time in retention and amount of relapse for the Hawley group or the bonded group ($P > 0.05$).

5. No significant relationship is found between initial irregularity and relapse ($P > 0.05$).

6. There was a significant difference in the number of bleeding points between the two groups ($P < 0.05$). The mean number of bleeding points for the Hawley group was

5.96, SD 7.3 and the mean number of bleeding points for the bonded group was 1.72, SD 1.24.

7. For the Hawley group, there was a significant positive relationship for bleeding on the canines and bleeding on the central and lateral incisors ($P<0.05$). There was no significant relationship for bleeding on the canines and bleeding on the central and lateral incisors for the bonded group ($P>0.05$).

8. There is no significant relationship for age and number of bleeding points ($P>0.05$).

9. No significant differences were found for the number of pockets (3.5 and above) between the two groups ($P > 0.05$). The mean number of pockets was 1.44, SD 2.97 for the Hawley group and .6, SD 1.68 for the bonded group.

10. There is no significant relationship for number of pockets and time in retention ($P>0.05$).

11. There is no significant relationship for age and number of pockets ($P>0.05$).

12. No difference for recession was found between the two groups ($P>0.05$).

13. There was no significant difference in age between the two groups ($P>0.05$). The mean for the Hawley group was 21.13, SD 6.4 and 22.79, SD 7.0 for the bonded group.

14. There was no evidence to show that the bonded maxillary retainer contributes to periodontal disease.

15. The bonded maxillary retainer appears to be a good retainer to keep upper incisors in good alignment for many years.

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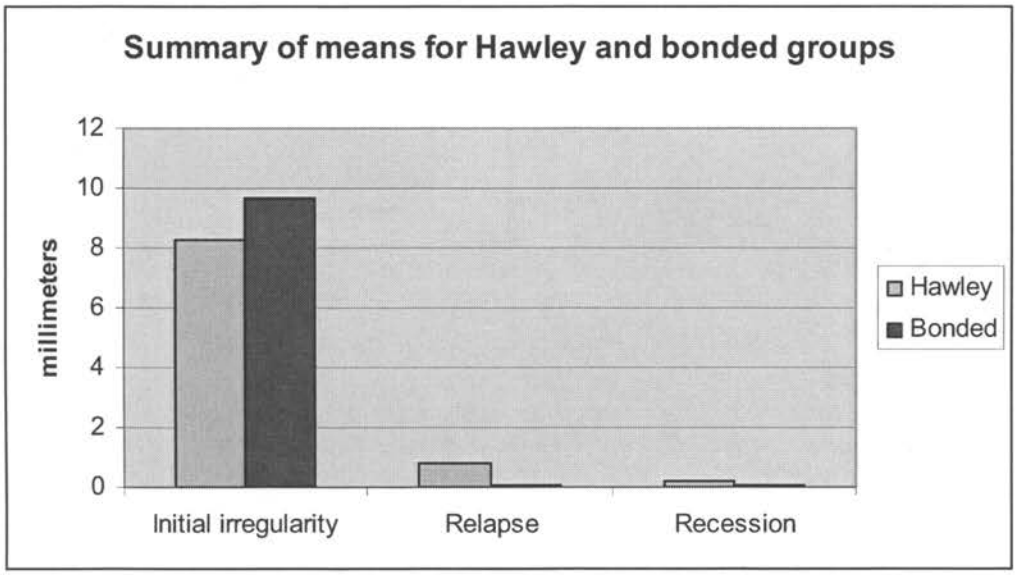
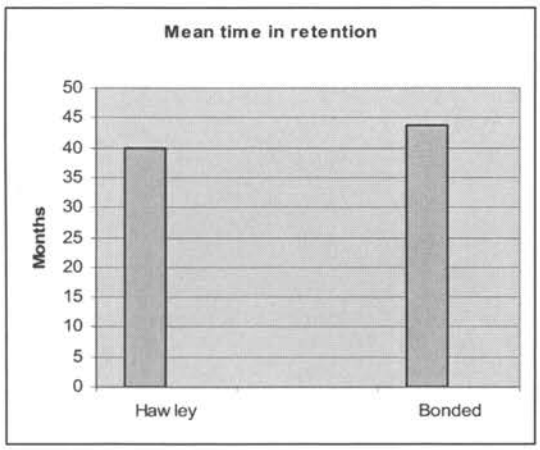
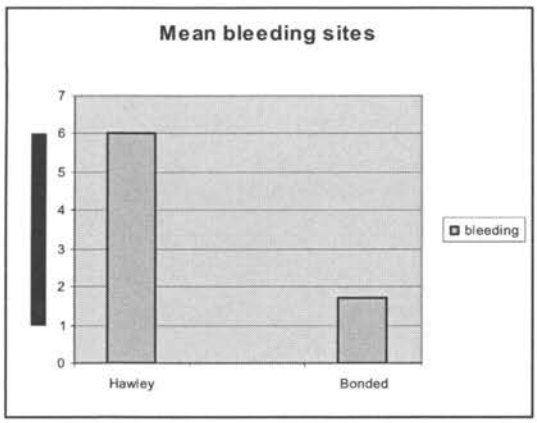
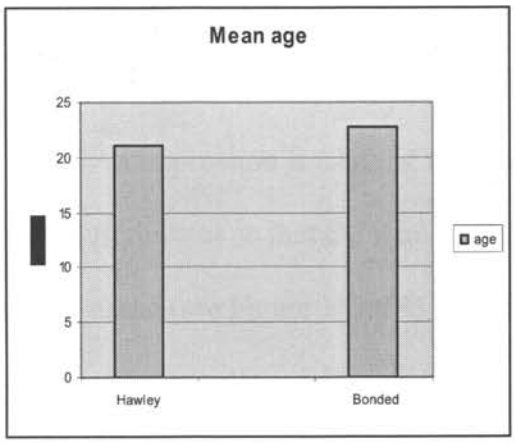
Appendix A:

Bar charts of Hawley and bonded group means








Mean age
25
20
15
10
5
0
Hawley
Bonded
age

Appendix B:

Technique:

An impression is taken of the maxillary anterior teeth and poured up. The wire is bent to fit the cast so that the wire rests passively on the tooth and its marginal ridges and palatal tissue (see Figure 1 and 2). Teeth are pumiced with a rubber cup on the lingual surface. The pumice is left in place and a green flame shaped polisher is used to clean out grooves when teeth are shovel-shaped. Teeth are rinsed and dried. The lingual surface is acid etched (35% phosphoric acid) for about 15 seconds then rinsed and dried. Bond-Rite 2-Step (from Ortho-Direct) is used as primer, lightly air dried then cured for 5 seconds. A small spatula is used to pick up and place some Light Bond light cured adhesive composite (Reliance Orthodontic Products Inc.) on the tooth. A cotton plier is used to pick up a U-shaped segment of the wire and the wire is seated into the composite to hold it in place. The plastic instrument is used to add more composite, shape the composite and position the wire. The retainer is then light cured for ten seconds. All three U-shaped segments are placed the same way. More composite is added so that each area has a nice contour and light cured again. The bite is checked for interference and adjusted if necessary. The margins are checked with a Shepards explorer, making sure that all areas are smooth, paying particular attention to the gingival margin. A thin green stone is used to shape the composite if necessary. Next, a white mounted rubber tip abrasive (small) is used to polish. Contacts are flossed to check for flash. Any flashed is removed with a #12 scalpel blade.

Appendix C:

Maxillary bonded 2-2 lingual retainer (description):

This modified fixed retainer has many potential benefits. It is easy to make. It also allows the palatal gum tissues to be cleaned easily with a tooth brush since it sits passively above the gingiva. Bristles can easily slip around and underneath the wire. Teeth are flossed directly without the use of a floss threader. Small to moderate size interproximal caries can be restored with this appliance in place if necessary. Being fixed, this appliance eliminates the need for patient compliance to retain the teeth. It is made out of a relatively thick and strong wire. The added length between the teeth (versus one straight wire spanning 2-2 or 3-3) wards off deformation and breakage and allows for physiologic tooth movement. It is not bonded to the maxillary canines, so they can function in canine rise. It has minimal bulk so patients should have minimal to no speech problems at delivery. It is very esthetic and should lessen the frequency of orthodontic re-treatment.

Appendix D:

Statistical analysis (Stata):

```
. regress relapse t1

      Source |       SS       df       MS              Number of obs =      50
-------------+------------------------------           F(  1,    48) =    0.96
       Model |  .856644044     1  .856644044            Prob > F      =  0.3332
    Residual |  43.0210379    48  .896271622            R-squared     =  0.0195
-------------+------------------------------           Adj R-squared = -0.0009
       Total |  43.8776819    49  .895462896            Root MSE      =  .94672

------------------------------------------------------------------------------
     relapse |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          t1 |  -.0381445   .0390168    -0.98   0.333    -.1165931    .0403041
       _cons |   .8023957   .3755179     2.14   0.038     .0473664    1.557425
------------------------------------------------------------------------------

.
. ttest relapse, by(bonding) unequal

Two-sample t test with unequal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |      25        .8348    .2409641    1.204821    .3374745    1.332125
       1 |      25         .084    .0576368    .288184    -.0349565    .2029565
---------+--------------------------------------------------------------------
combined |      50        .4594    .1338255    .946289     .1904676    .7283324
---------+--------------------------------------------------------------------
    diff |               .7508    .2477614                .2422018    1.259398
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =   3.0303
Ho: diff = 0                     Satterthwaite's degrees of freedom =  26.7373

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9973         Pr(|T| > |t|) = 0.0054          Pr(T > t) = 0.0027

. robvar relapse , by(bonding)

        |       Summary of relapse
   bonding |      Mean   Std. Dev.       Freq.
------------+------------------------------------
          0 |      0.83       1.20         25
          1 |      0.08       0.29         25
------------+------------------------------------
      Total |      0.46       0.95         50

W0 =  14.696001  df(1, 48)    Pr > F = 0.00036747

W50 =  14.740148  df(1, 48)    Pr > F = 0.00036095

W10 =  14.519858  df(1, 48)    Pr > F = 0.00039471

. ttest bleed , by(bonding) unequal

Two-sample t test with unequal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |      25        5.96        1.46        7.3    2.946708    8.973292
       1 |      25        1.72    .2484619    1.24231      1.2072      2.2328
---------+--------------------------------------------------------------------
combined |      50        3.84    .7930103   5.607429    2.246386    5.433614
---------+--------------------------------------------------------------------
```

```
   diff |        4.24    1.480991                1.19221    7.28779
------------------------------------------------------------------------------
   diff = mean(0) - mean(1)                                      t =   2.8629
Ho: diff = 0                     Satterthwaite's degrees of freedom =  25.389

   Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9959         Pr(|T| > |t|) = 0.0083          Pr(T > t) = 0.0041

. robvar bleed , by(bonding)

        |        Summary of bleed
   bonding |      Mean   Std. Dev.       Freq.
------------+------------------------------------
          0 |      5.96       7.30         25
          1 |      1.72       1.24         25
------------+------------------------------------
      Total |      3.84       5.61         50

W0 = 19.0208189  df(1, 48)    Pr > F = 0.00006816

W50 =  8.2347981  df(1, 48)    Pr > F = 0.00609378

W10 = 11.2048280  df(1, 48)    Pr > F = 0.00159286

.
. ttest pockets , by(bonding)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |   Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |    25        1.44    .5946427    2.973214    .2127177    2.667282
       1 |    25          .6    .3366502    1.683251   -.0948118    1.294812
---------+--------------------------------------------------------------------
combined |    50        1.02     .34344    2.428487    .3298315    1.710168
---------+--------------------------------------------------------------------
   diff |              .84    .6833252               -.5339174    2.213917
------------------------------------------------------------------------------
   diff = mean(0) - mean(1)                                      t =   1.2293
Ho: diff = 0                                 degrees of freedom =       48

   Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.8875         Pr(|T| > |t|) = 0.2250          Pr(T > t) = 0.1125

. ttest t1 , by(bonding)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |   Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |    25      8.2876    .6531006    3.265503    6.939667    9.635533
       1 |    25      9.6964    .7164998    3.582499    8.217617    11.17518
---------+--------------------------------------------------------------------
combined |    50       8.992    .4902129    3.466329     8.00688     9.97712
---------+--------------------------------------------------------------------
   diff |            -1.4088    .9694908               -3.358092    .5404918
------------------------------------------------------------------------------
   diff = mean(0) - mean(1)                                      t =  -1.4531
Ho: diff = 0                                 degrees of freedom =       48

   Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0763         Pr(|T| > |t|) = 0.1527          Pr(T > t) = 0.9237

. ttest age , by(bonding)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |   Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |    25    21.12808     1.2825     6.4125    18.48113    23.77503
```

```
    1 |    25   22.79156   1.403002   7.015009   19.89591   25.68721
---------+--------------------------------------------------------------------
combined |    50   21.95982    .94815   6.704433   20.05444    23.8652
---------+--------------------------------------------------------------------
    diff |         -1.66348   1.900847              -5.485389   2.158429
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =  -0.8751
Ho: diff = 0                     degrees of freedom =       48

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.1929         Pr(|T| > |t|) = 0.3859          Pr(T > t) = 0.8071

. ttest recess , by(bonding)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |   Obs       Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |    25        .18   .1604161    .8020806   -.1510826    .5110826
       1 |    25        .06   .0439697    .2198484    -.030749     .150749
---------+--------------------------------------------------------------------
combined |    50        .12   .0827586    .5851914   -.0463096    .2863096
---------+--------------------------------------------------------------------
    diff |              .12    .166333               -.2144349    .4544349
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =   0.7214
Ho: diff = 0                     degrees of freedom =       48

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.7629         Pr(|T| > |t|) = 0.4741          Pr(T > t) = 0.2371

. ttest ret_time , by(bonding)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |   Obs       Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |    25      39.92   8.899798   44.49899   21.55172    58.28828
       1 |    25      43.76   9.309543   46.54772   24.54605    62.97395
---------+--------------------------------------------------------------------
combined |    50      41.84   6.379454   45.10955   29.02001    54.65999
---------+--------------------------------------------------------------------
    diff |             -3.84   12.87921              -29.73538   22.05538
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =  -0.2982
Ho: diff = 0                     degrees of freedom =       48

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.3834         Pr(|T| > |t|) = 0.7669          Pr(T > t) = 0.6166



             | relapse      t1
-------------+------------------
    relapse |  1.0000
            |
            |
         t1 | -0.1397   1.0000
            |  0.3332
            |

. //regress relapse t1
.
. scatter relapse ret_time

. graph rename relapse_vs_rettime

. pwcorr relapse ret_time , sig

             | relapse ret_time
```

```
-------------+------------------
    relapse |  1.0000
            |
            |
   ret_time |  -0.2728   1.0000
            |   0.0553
            |

.
. scatter bleed age

. graph rename bleed_vs_age

. pwcorr bleed age , sig

            |   bleed      age
-------------+------------------
      bleed |  1.0000
            |
            |
        age |  -0.0742   1.0000
            |   0.6085
            |

.
. scatter pockets age

. graph rename pockets_vs_age

. pwcorr pockets age , sig

            |  pockets      age
-------------+------------------
    pockets |  1.0000
            |
            |
        age |  -0.0602   1.0000
            |   0.6778
            |
.
. scatter bleed ret_time

. graph rename bleed_vs_rettime

. pwcorr bleed ret_time , sig

            |    bleed ret_time
-------------+------------------
      bleed |  1.0000
            |
            |
   ret_time |   0.0112   1.0000
            |   0.9385
            |

.
. scatter pockets ret_time

. graph rename pockets_vs_rettime

. pwcorr pockets ret_time , sig

            |  pockets ret_time
-------------+------------------
    pockets |  1.0000
            |
            |
   ret_time |  -0.1019   1.0000
            |   0.4815
```