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Periodontal Health of Anterior Teeth with Two Types of Fixed Retainers

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Periodontal Health of Anterior Teeth with Two Types of Fixed Retainers

by

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A thesis submitted in partial satisfaction of
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Each person whose signature appears below certifies that this thesis in his/her opinion is adequate, in scope and quality, as a thesis for the degree Master of Science.

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ABBREVIATIONS

SR	Straight Retainer
WR	Wave Retainer
PPD	Pocket Probing Depths
PI	Plaque Index
CI	Calculus Index
BOP	Bleeding on Probing
REC	Gingival Recession
GCFV	Gingival Crevicular Fluid Volume
ISMT	Independent Samples Median Test
MWU	Independent Samples Mann-Whitney U Test

ABSTRACT OF THE THESIS

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Master of Science, Graduate Program in Orthodontics and Dentofacial Orthopedics
Loma Linda University, September 2013
Dr. V. Leroy Leggitt, Chairperson

Introduction: Fixed retainers for anterior teeth have become a popular method for maintaining the position and function of teeth after orthodontic treatment. Various retainer designs, wire sizes and types have been used over the years. One problem with fixed retainers is that they complicate oral hygiene and therefore might negatively affect the periodontal tissues if left in place for long periods of time.

Purpose: The purpose of this study is to compare the periodontal health of maxillary and mandibular anterior teeth retained with two different types of fixed retainers.

Methods: Male and female subjects who had been in continuous orthodontic fixed retention for between 2-4 years were recruited from a single, private orthodontic practice in southwestern British Columbia. The periodontal health of the anterior teeth of 39 subjects with a wave retainer and 35 subjects with a straight retainer between the ages of 13-22 were evaluated. Pocket probing depths, bleeding on probing, plaque index, calculus index, recession and gingival crevicular fluid volume were recorded and compared to determine if there was any significant difference between the two groups. Additionally, a ten-question oral hygiene survey to assess each subject's oral hygiene habits was given to each subject at the time of data collection.

Results: The Independent Samples Median Test and Mann-Whitney U test indicated that there was no statistically significant difference between the groups regarding plaque index, gingival crevicular fluid volume, calculus index and pocket probing depths. The Mann-Whitney U test indicated that there was no statistically significant difference in recession and bleeding on probing between the groups. The Mann-Whitney U test indicated a statistically significant difference in the reported frequency of flossing (P =0.006) and ease of flossing (P =0.000), with the wave retainer group reporting flossing more frequently and with greater ease. Using the Mann-Whitney U test there was no significant difference between the groups for reported frequency of brushing and comfort of retainer.

Conclusion: Under the conditions of this study, no difference was found in the periodontal health of anterior teeth retained with a straight or wave retainer for a period of 2-4 years following orthodontic treatment. Subjects reported an increase in frequency and ease of flossing for the fixed wave retainer compared to those with a straight retainer.

CHAPTER ONE

INTRODUCTION

Statement of the Problem

The V-Loop retainer first introduced by Lew in 1989 and more recently a modified v-loop or "wave" retainer are fixed retainers that scallop the wire toward the soft tissues around the retained teeth in order to make oral hygiene less complicated for patients. The position of the lower loop of the retainer is just slightly relieved from the lingual interdental papilla to allow for normal flossing technique to be used during routine oral hygiene. The wave retainer was designed with the hope that oral hygiene, especially flossing, would be easier and thus improve patient compliance and the periodontal health of the teeth associated with fixed retainers.

One possible drawback of the wave retainer is that the lingual loop near the gingival tissues might actually increase gingival recession, inflammation, as well as plaque and calculus accumulation.

This study was designed to evaluate the periodontal health of the teeth associated with these two types of fixed retainers.

Hypotheses

The null hypothesis was that there will be no difference between the periodontal health and oral hygiene of maxillary and mandibular anterior teeth retained with a straight or a wave fixed retainer. The alternative hypothesis was that there will be a

significant difference between the two groups with the wave retainer contributing to improved periodontal health as measured by the parameters of this study.

CHAPTER TWO

REVIEW OF THE LITERATURE

History of Fixed Retainers

Retention of orthodontic treatment results has long been a matter of clinical and practical importance to orthodontists and their patients.[1,2,3] Retention has been defined in many ways but usually it refers to holding the teeth in an optimal esthetic and functional position following orthodontic treatment[1]. Retention is necessary to maintain the treatment result and achieve stability of the dentition in its new relationships due to soft and hard tissue remodeling.[2,4]

Removable retainers for both upper and lower arches were for many years the only form of retention used by orthodontists. However, in the 1970s bonded fixed retainers were introduced into clinical practice to retain the lower anterior teeth in post orthodontic treatment positions.[5] As time has passed, orthodontists have concluded that the best way to maintain ideal alignment of teeth in post orthodontic treatment positions is to utilize some form of long-term or even permanent retention.[6,7,8,9]

In 2002 a survey found that approximately one-third of orthodontic practitioners used fixed retainers for the mandibular anterior teeth and about 5% use fixed retainers for the maxillary anterior teeth.[9] In 2011 a retention protocol survey found that among the respondents to the survey, 42% used fixed retainers in the mandibular arch and 11% in the maxillary arch.[10]

Littlewood in a Cochrane Review in 2004 found that there was insufficient research

data at that time on which orthodontists could base their clinical practice of retention.[11] The authors went on to say that "there is an urgent need for high quality randomized controlled trials in this crucial area of orthodontic practice."[11] Apparently there are widely held beliefs and practices with regards to orthodontic retention that are not supported by an evidence-based approach to treatment decision-making.

Advantages and Disadvantages

The advantages of fixed retainers over removable retainers are 1) they are not visible when viewing the patient from the front, since they are bonded to the lingual surfaces of the teeth, 2) they are well tolerated by patients and 3) they are compliance free.[5,9] The disadvantages of these retainers are that: 1) placement is technique sensitive, 2) they are subject to bonding failures[5], 3) there are increased plaque and calculus accumulations associated with fixed retainers compared to removable retainers[5,12,13] and 4) they are not adjustable. In spite of this, it has been reported that the clinical experience with bonded lingual retainers in the mandibular anterior teeth has been excellent when careful adaptation and bonding techniques are used in the process of delivery.[6]

Trends

Fixed retainers, over the years, have been made from numerous types and sizes of wires. Some orthodontists use a 0.032 inch round stainless steel wire fitted to the lingual surface of the mandibular canine-to-canine teeth and bonded at the ends. Others use a 0.032 inch spiral or braided three-strand wire. Sometimes, the practitioner chooses to use a lighter wire such as 0.0215 inch flexible twisted three-strand wire bonded to each

tooth.[1,9] More recently, new materials such as fiber-reinforced-plastic bonded retainers have been used that indicate in time they may become a viable alternative to fixed metal wire retainers.[14] The choice of resin adhesive also seems to vary from practitioner to practitioner depending on what materials they are used to using in other aspects of their clinical practice. Although the wires and bonding materials vary, fixed retainers should allow for physiologic tooth movement[2] while retaining the teeth in their optimal finished position.

The use of mandibular fixed retainers has increased, with a lesser increase in the use of maxillary fixed retainers. Aside from the commonly used short fixed wire retainer from one adjacent incisor to another to hold a diastema closed upon completion of treatment, few orthodontists routinely use fixed retention in the maxillary anterior teeth.[9] This difference may be due to increased complexities such as bite clearing associated with maxillary fixed retention.[5] Bonding a fixed retainer in the maxillary arch is more complicated as the opposing mandibular incisors often occlude with the wire or adhesive. This makes a more gingival location of the wire necessary to avoid premature contacts and could potentially promote negative gingival and periodontal reactions.[5,15]

Conflict Regarding Oral Health and Fixed Retainers

The widespread use of fixed retainers has raised concern among practitioners about a possible decline in periodontal health. It is thought that removable retainers do not complicate oral health and hygiene since they can be easily removed while a person is performing their oral hygiene routine.[16]

Artun has found no association between bonded retainers of different wire types

and caries developement.[12] This finding was made even though greater plaque accumulations along the wires used for fixed retainers was noted.[12,17]

The literature was not consistent on the question of periodontal and gingival health associated with lingual fixed retainers. Levin et al., found that fixed retainers have been associated with an increase in gingival recession, plaque retention and bleeding on probing.[18]

It has also been suggested that fixed retainers have some influence on other aspects of periodontal health.[15] Pandis et al., seemed to support this conclusion when he stated that long term fixed retainer wear causes greater calculus accumulations, marginal recession and increased probing depths likely associated with long term irritation of the tissue induced by the fixed retainer.[5] It also seems that the length of time the bonded retainer is in place is more related to plaque and calculus accumulation than the type or size of wire used for the retainer.[12] Areas gingival to the wire and inter-proximally have been shown to accumulate deposits of plaque and calculus since wire crossing the interdental region creates an area that is difficult to clean.[4,5,9] Other studies have shown no apparent damage to hard tissues, including bone levels, even though there was evidence for some soft tissue effects.[5,13]

Booth et al., found that long-term retention of mandibular incisors with fixed retention appears acceptable to most patients and compatible with periodontal health.[19] A more recent study by Rody et al., found that the clinical periodontal health of subjects was not affected by bonded lingual retainers despite increased plaque accumulations in the lower incisor region.[13]

In spite of these differences, the literature generally appears to agree that fixed

lingual retainers complicate oral hygiene procedures for the patients.[17] When bonded retainers are placed, patients must be educated on maintenance that includes some form of interdental cleaning aid (i.e. Superfloss or a floss threader).[4] Whether the mandibular retainer is bonded to each anterior tooth or to as few as two teeth, flossing should be completed by individually threading the floss between the teeth that are bonded to the retainer and underneath the wire using a floss threader or some other similar device to allow inter-proximal access for cleaning.[4,17] This process complicates oral hygiene and suggests that patient's attitudes and motivation are very important considerations in deciding whether or not to place a fixed retainer.[13] Bonding to each tooth may also restrict access of the toothbrush to interdental areas, limit the ability of floss to slide freely from canine to canine and may lead to an overall decline in maintenance and compliance.[17]

Development of the V-Loop Retainer

As the use of fixed retainers has gained in popularity, their design has remained relatively unchanged. Most are made of a straight, single stranded or braided stainless steel wire intimately adapted to the lingual surface of the teeth and placed at or slightly above the cingulum.[20] It wasn't until 1989 that Lew, in an attempt to address issues of oral hygiene and plaque accumulation proposed a new design of fixed retainer called the V-Loop retainer.[17] This retainer was designed with loops or "V" portions that crossed the interdental papillae at levels that allowed for normal flossing technique to be employed without the need for interdental cleansing aids.[16,17]

Current Positions in Literature

Despite complications to oral hygiene some researchers have concluded that fixed retainers do not have a negative effect on a patient's ability to achieve satisfactory hygiene.[12,13,15] Artun et al., has suggested that with a professional cleaning and a session on maintenance every six months it is unlikely that a patient's periodontal health would be compromised.[15] This indicates that close monitoring is important for patients in which a fixed retainer has been placed as a form of short or long-term retention.[5]

Wellington et al., in a study that evaluated gingival crevicular fluid volume (GCFV) as one of the measurements of inflammation, found that a tendency toward increased volume of GCFV in the mandibular incisor region was not statistically significant.[13] In another study, Levin et al., found that fixed retainers placed closer to the gingival tissues had greater gingival recession and inflammation associated with them when compared to more incisally placed fixed retainers.[18] Artun has also found in earlier studies that fixed retainers had more accumulation of plaque and calculus gingivally than incisally and attributes this finding to potentially better brushing by patients incisally than gingivally.[12] There was also evidence that more plaque accumulates on the distal surfaces of teeth of patients with multi-strand wire retainers than with round single strand wire retainers.[12] These findings indicated that fixed retainers should be placed as far as possible from the gingival margin to prevent oral hygiene impairment[21] and to decrease any potential inflammatory response of the gingival tissues such as recession and increased bleeding.

The V-loop, or wave retainer as some orthodontists have called it, would seem to increase the chance that gingival tissues would become irritated. The loops are formed to drop down and cross the interdental papillae apical enough to allow for normal flossing

technique to be used between teeth. At this level the loop of the retainer is only slightly relieved from the gingival tissues.

CHAPTER THREE

METHODS AND MATERIALS

This research project was designed to be an observational cross-sectional study. It required the collection of data commonly recorded during routine dental prophylaxis appointments, an intra-oral photograph of the maxillary and mandibular anterior teeth, and a brief survey of oral hygiene habits. The data on straight wire retainers was collected on maxillary anterior teeth retained with a 0.546 mm (0.0215 inch) Tri-Flex™ stainless steel twisted 3 strand orthodontic wire from Rocky Mountain Orthodontics (Denver, CO) and mandibular anterior teeth retained with a 0.8 mm twisted stainless steel wire from 3M® Unitek (Monrovia, CA) (Fig 1).

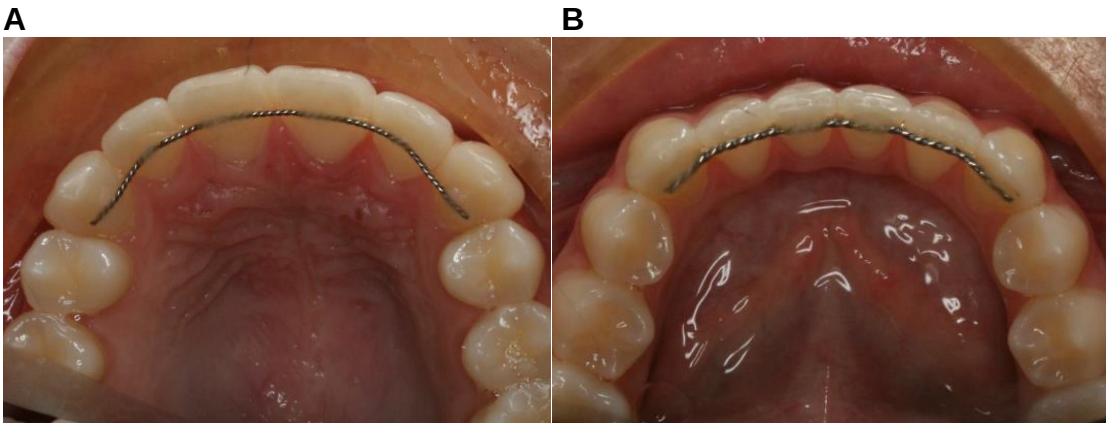

Fig 1. Maxillary and Mandibular Straight Retainers. A: Maxillary straight retainer, B: Mandibular straight retainer.

The wave retainer data was collected on maxillary and mandibular anterior teeth fixed with a 0.569 mm (0.022 inch) Blue Elgiloy® (soft) round wire from Rocky

Mountain Orthodontics (Fig 2).

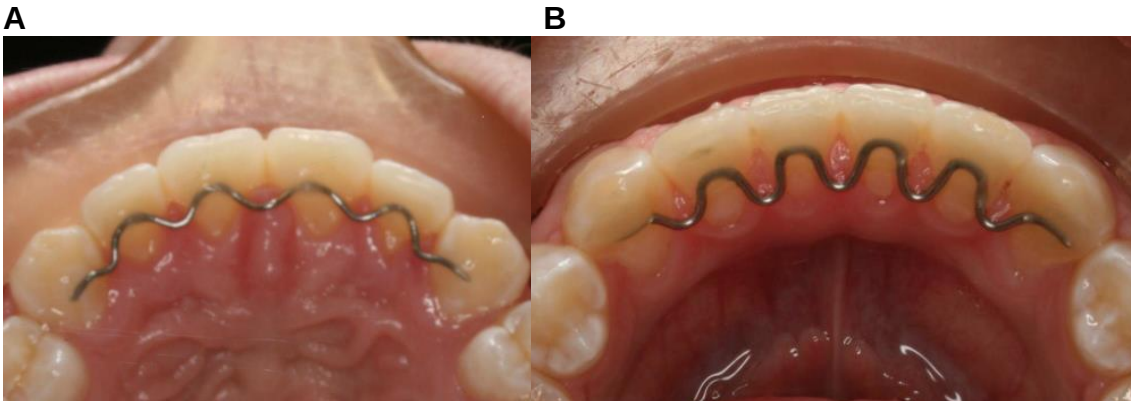

Fig 2. Maxillary and Mandibular Wave Retainers. A: Maxillary wave retainer, B: Mandibular wave retainer.

The study sample included 35 subjects with the straight twisted wire retainer (SR) and 39 subjects with the v-loop or wave-type (WR) retainer. All subjects in this study were selected from a single private orthodontic practice located in southwestern British Columbia, Canada. This study was reviewed and approved by the Institutional Review Board of Loma Linda University.

Males and females who were between the ages of 13-22 years old and in post orthodontic treatment continuous fixed retention for between 24 and 48 months were included in this study. A list of potential subjects who had been debanded within the time period of interest and met the inclusion criteria were consecutively called until the sample size for both groups had been met.

Exclusion criteria included: 1) a professional dental cleaning within the last 4 months, 2) history of diabetes, 3) habit of smoking, 4) pre-existing periodontal disease, 5) diagnosed with periodontal disease subsequent to orthodontic treatment, 6) required antibiotic prophylaxis prior to periodontal data collection, 7) those currently taking

antibiotics, and 8) those who were pregnant.

For this study the FDI World Dental Federation notation system was used to identify teeth. There were 6 measures of periodontal health collected on each subject.

1. The Loe Plaque Index (PI) with the following scores used for plaque accumulation measurements. Zero (0): No plaque in the gingival area, One (1): No plaque visible by the unaided eye, but plaque is made visible on the point of the probe after it has been moved across surface at entrance of the gingival crevice, Two (2): Gingival area is covered with a thin to moderately thick layer of plaque; deposit is visible to the naked eye, Three (3): Heavy accumulation of soft matter, the thickness of which fills out niche produced by the gingival margin and tooth surface; interdental area is stuffed with soft debris.[22]
2. Gingival Crevicular Fluid Volume was measured with the Periotron 8000 from Oraflow™ Inc. Periopaper™ gingival fluid collection strips were used for instrument calibration and crevicular fluid collection from each subject. A calibration curve was constructed using known volumes of distilled water at 0.25 ul, 0.50 ul, 0.75 ul, 1.00 ul, 1.25 ul dispensed with an Eppendorf Research (fixed-volume) pipette. The computer software on which the analysis was completed was the Periotron Professional (v3.0a). Plaque and/or calculus accumulations that interfered with the collection of crevicular fluid were removed before each sample was collected. Four (4) sites were chosen for fluid collection: the direct facial and lingual sulcus of an upper and lower right central incisor. Each site was gently air dried for approximately 5 seconds and isolated from saliva with cotton rolls as necessary. Two strips of Periopaper were individually inserted into the gingival sulcus for 5 seconds with 30 seconds between samplings.

Two samples per site were taken for a total of eight samples. Each periopaper strip was immediately placed between the counterparts of the Peritron 8000 and the Periotron score recorded. The Periotron score for each collection site was averaged and entered into the Periotron Professional software from which a volume of fluid was determined by the Periotron computer program using interpolation from the standard curve developed from the instrument calibration.

3. The Greene and Vermilion Calculus Index (CI) with a scale of 0-3: Zero (0) being no calculus; One (1) being supragingival calculus present covering not more than 1/3 of the tooth surface; Two (2) being supragingival calculus present covering between 1/3 and 2/3 of the tooth surface or scattered subgingival calculus; and Three (3) being supragingival calculus covering more than 2/3 of the tooth surface or a continuous ring of subgingival calculus.[23]
4. Gingival pocket probing depths (PPD) were measured with a standard periodontal probe manufactured by G. Hartzell & Son. Each increment represented 2.0mm. Sulcular pocket depths were measured at six (6) locations around each study tooth, mesial buccal (MB), direct facial (F), distal buccal (DB), distal lingual (DL), direct lingual (L), and mesial lingual (ML). The PPD was recorded to the nearest millimeter for each site and entered into the research record.
5. Gingival recession (REC) to the nearest millimeter from the cemento-enamel junction to the free gingival margin was recorded for the direct facial and direct lingual surfaces of each anterior tooth using the same periodontal probe as used for PPD.
6. Bleeding on probing (BOP) that occurred within 30 seconds of making a PPD measurement anywhere along the gingival sulcus was recorded as a yes (Y) or no (N).

7. An oral hygiene questionnaire with 10 questions was given to each subject at the time of the clinical exam that asked for subject's frequency of brushing, flossing, use of mouth rinse, brand of mouth rinse, ease of flossing, interdental cleaning aid used, comfort of retainers and time to complete oral hygiene (Appendix A).

One examiner collected the research data on all subjects during a one-week period of time. The sequence of data collection was PI, GCFV, CI, PPD, BOP, REC. If any pathologic condition was discovered during the data collection the patient was informed of the finding and referred to the appropriate dental professional for follow-up care.

Calibration of data collection techniques of the examiner was conducted with a licensed periodontist prior to the collection of research data. An intraclass correlation coefficient of 0.907 with a 95% confidence interval was obtained from an analysis of the combined data. The lower and upper bounds were 0.886 and 0.924 respectively.

Table I: Examiner Calibration Summary

		95% Confidence Interval	
	Intraclass Correlation[a]	Lower Bound	Upper Bound
Single Measures	.907[b]	.886	.924

Statistical Analysis

The Independent Samples Median test (ISMT) and Mann-Whitney U test (MWU) were used to compare the groups with respect to plaque index, gingival crevicular fluid volume, calculus index, pocket probing depths and responses to the oral hygiene questionnaire between the groups. The MWU test was used to compare gingival

recession. Fisher's Exact test for categorical data was used to analyze the bleeding on probing scores.

CHAPTER FOUR

RESULTS

A summary of demographic data is presented in Table II. The mean age for the SR group was 18 years old and the mean retention time was 42 months. The standard deviation was 1.3 and 2.4 years respectively. The mean age for the WR group was 17 years old and the mean retention time was 32 months. The standard deviation was 0.96 and 3.2 respectively. See Appendix B for a more detailed summary of the demographic data.

Table II: Summary of Demographic Data

DEMOGRAPHIC DATA	WAVE n=39 mean(SD)	STRAIGHT n=35 mean(SD)	P Value Independent Samples Median Test	P Value Mann Whitney U Test
Sex (M/F)	13/26	17/28		
Age (years)	16.9(0.96)	18.3(1.3)	0.004*	0.000*
Retention (months)	31.6(3.2)	42.3(2.4)	0.000*	0.000*

*Significance at P <0.05 level.

The ISMT and MWU test showed P values of 0.004 and 0.000 respectively for age. These same tests showed P values of 0.000 for both the median and distribution of retention time. There was a significant difference both in the median and distribution of the groups regarding age and retention time. See Appendix C and D for box plots of age and retention data.

An analysis of the plaque index using the ISMT indicates that there was no

significant difference in the median of the two groups with P values ranging from 0.097 to 0.962. The MWU test indicated statistical significance for tooth numbers 23 and 33 with P values of 0.032 and 0.041 respectively. The remaining P values ranged from 0.08 to 0.446. See Tables III and IV for summary statistics.

Table III. Plaque Index Maxillary Teeth

Tooth	Wave (mean/SD)	Straight (mean/SD)	P-Value (ISMT)	P-Value (MWU)
13	1.82/0.683	2.09/0.742	0.173	0.117
12	1.87/0.732	2.17/0.664	0.281	0.08
11	1.92/0.703	2.06/0.793	0.543	0.421
21	1.85/0.709	1.97/0.664	0.942	0.417
22	1.82/0.790	2.11/0.631	0.799	0.092
23	1.69/0.766	2.09/0.742	0.173	0.032*

*Significance at 0.05 level.

Table IV. Plaque Index Mandibular Teeth

Tooth	Wave (mean/SD)	Straight (mean/SD)	P-Value (ISMT)	P-Value (MWU)
43	1.95/0.793	2.09/0.742	0.962	0.446
42	1.85/0.812	2.09/0.742	0.585	0.208
41	1.79/0.732	2.09/0.781	0.281	0.076
31	1.86/0.713	2.06/0.814	0.305	0.232
32	1.74/0.715	2.03/0.785	0.173	0.113
33	1.72/0.686	2.06/0.802	0.097	0.041*

*Significance at 0.05 level.

Statistical analysis of gingival crevicular fluid volume using the ISMT and MWU test indicated no significant difference between the two retainer groups. P values ranged from 0.257 to 0.980 and 0.303 to 0.914 respectively. See Table V for summary of statistics.

Table V. Gingival Crevicular Fluid Volume Summary Data

Tooth	Wave (mean/SD)	Straight (mean/SD)	P-Value (ISMT)	P-Value (MWU)
11F	0.1054/0.06349	0.1086/0.05786	0.507	0.58
11L	0.1646/0.18186	0.1120/0.05764	0.786	0.303
41F	0.0762/0.05856	0.0889/0.06197	0.826	0.467
41L	0.2064/0.17059	0.1957/0.14551	0.98	0.914

The ISMT and MWU test for the calculus index indicated there was no significant difference between the two retainer groups in terms of calculus accumulation. P values ranged from 0.129 to 0.957 and 0.994 respectively. See Tables VI and VII for a summary of statistical data.

Table VI. Calculus Index Maxillary Teeth

Tooth	Wave (mean/SD)	Straight (mean/SD)	P-Value (ISMT)	P-Value (MWU)
13	0.10/0.307	0.17/0.382	0.6	0.39
12	0.18/0.389	0.23/0.426	0.814	0.602
11	0.21/0.409	0.21/0.410	0.778	0.994
21	0.13/0.339	0.26/0.443	0.264	0.16
22	0.21/0.409	0.17/0.382	0.942	0.714
23	0.21/0.409	0.06/0.236	0.129	0.065

Table VII. Calculus Index Mandibular Teeth

Tooth	Wave (mean/SD)	Straight (mean/SD)	P-Value (ISMT)	P-Value (MWU)
43	0.49/0.601	0.51/0.507	0.659	0.66
42	0.87/0.469	0.69/0.583	0.687	0.11
41	1.00/0.562	0.94/0.639	0.912	0.673
31	0.97/0.552	1.03/0.627	0.633	0.685
32	0.87/0.522	0.71/0.519	0.687	0.204
33	0.56/0.552	0.60/0.497	0.957	0.694

The ISMT for gingival pocket probing depths indicated no significant differences between the groups with P values ranging from 0.084 to 0.957. Using the MWU test, an indication of statistical significance was found for tooth number 41 with a P value of 0.036. The remaining P values ranged from 0.124 to 0.965. See Tables VIII and IX for summary statistics.

Table VIII. Pocket Probing Depth for Maxillary Teeth

Tooth	Wave (mean/SD)	Straight (mean/SD)	P-Value (ISMT)	P-Value (MWU)
13	2.90/0.502	2.83/0.514	0.9	0.558
12	2.87/0.469	2.71/0.458	0.522	0.165
11	2.92/0.480	2.91/0.514	0.801	0.912
21	2.79/0.570	2.69/0.530	0.687	0.427
22	2.79/0.69	2.71/0.519	0.522	0.463
23	2.82/0.506	2.77/0.490	0.924	0.69

Table IX. Pocket Probing Depth for Mandibular Teeth

Tooth	Wave (mean/SD)	Straight (mean/SD)	P-Value (ISMT)	P-Value (MWU)
43	2.92/0.270	2.94/0.416	0.426	0.841
42	3.00/0.513	2.83/0.382	0.084	0.124
41	2.85/0.540	2.60/0.651	0.687	0.036*
31	2.78/0.672	2.62/0.652	0.669	0.245
32	2.85/0.540	2.83/0.382	0.278	0.965
33	2.87/0.339	2.94/0.338	0.957	0.379

*Significance at 0.05 level.

No significant difference was found for recession between the two groups using the MWU test. P values ranged from 0.119 to 1.00. See Tables X-XIII for summary statistics.

Table X. Recession Maxillary Right Teeth

Tooth	Wave (mean/SD)	Straight (mean/SD)	P-Value (MWU)
13F	0.00/0.00	-0.03/0.171	0.284
13L	0.00/0.00	-0.03/0.169	0.291
12F	-0.03/0.160	0.00/0.00	0.343
12L	-0.03/0.160	0.00/0.00	0.343
11F	0.00/0.00	-0.03/0.171	0.284
11L	0.00/0.00	0.00/0.00	1

Table XI. Recession Maxillary Left Teeth

Tooth	Wave (mean/SD)	Straight (mean/SD)	P-Value (MWU)
21F	-0.03/0.160	-0.03/0.170	0.939
21L	0.00/0.00	0.00/0.00	1
22F	-0.03/0.160	0.00/0.00	0.343
22L	0.00/0.00	0.00/0.00	1
23F	-0.03/0.160	0.00/0.00	0.343
23L	0.00/0.00	0.00/0.00	1

Table XII. Recession Mandibular Right Teeth

Tooth	Wave (mean/SD)	Straight (mean/SD)	P-Value (MWU)
43F	-0.05/0.223	-0.09/0.373	0.89
43L	-0.05/0.223	-0.06/0.236	0.912
42F	0.00/0.00	0.00/0.00	1
42L	-0.13/0.339	-0.03/0.169	0.119
41F	-0.05/0.320	-0.03/0.169	0.954
41L	-0.08/0.270	-0.11/0.323	0.586

Table XIII. Recession Mandibular Left Teeth

Tooth	Wave (mean/SD)	Straight (mean/SD)	P-Value (MWU)
31F	-0.03/0.164	0.00/0.00	0.338
31L	-0.05/0.229	-0.06/0.239	0.931
32F	0.00/0.00	0.00/0.00	1
32L	-0.05/0.223	-0.06/0.236	0.912
33F	0.00/0.00	-0.03/0.169	0.291
33L	-0.03/0.160	-0.09/0.284	0.257

Bleeding on probing along the gingival sulcus that occurred within 30 seconds of probing was recorded as "yes" or "no". Fisher's Exact test for categorical data indicated no significant difference between the two groups. P values ranged from 0.089 to 1.00. See Table XIV.

Table XIV. Bleeding on Probing Summary Data

Tooth	Wave (Y/N)	Straight (Y/N)	Fisher's Exact Test
11	26/13	22/12	1.00
12	23/16	27/8	0.136
13	15/24	16/19	0.638
21	20/19	25/10	0.097
22	24/15	20/15	0.814
23	22/17	18/17	0.816
41	29/10	29/6	0.411
42	31/4	28/11	0.089
43	23/16	22/13	0.814
31	26/11	25/9	0.797
32	27/12	25/10	1.00
33	21/18	17/18	0.816

The self-reported oral hygiene survey results indicated a signifcant difference in frequency of flossing and ease of flossing, P=0.006 and P=0.000 respectively, using the

MWU test.

For the SR group a range of 0 to 2 was reported for frequency of flossing. 60% of subjects in this group indicated never flossing, 28.6% reported flossing 2-3 times per week and 11.4% flossesd 1 time/day.

The WR group reported a range of 0-3 for frequency of flossing. 30.8% reported never flossing. 38.5% reported flossing 2-3 times per week. 23.1% reported flossing 1 time/day and 7.7% reported flossing 2 or more times per day.

Essentially twice as many subjects with a WR reported flossing 1 time/day as compared to the SR group. Almost 2/3 of the SR group reported never flossing, while only about 1/3 of subjects with a WR reported never flossing. See Appendix E for summary data of frequency of flossing.

The SR group data indicated that ease of flossing was between very difficult and easy. 25.7% rated flossing as very difficult and 17.1% rated it as difficult. 42.9% said flossing was somewhat difficult and 14.3% said that flossing was easy.

For the WR group none reported flossing as very difficult. Only 2.6% of subjects rated flossing as difficult and 5.1% rated it as somewhat difficult. 43.6% rated flossing as easy and 46.2% rated flossing as very easy. See Appendix F for summary data on ease of flossing.

Retainer comfort and frequency of brushing was found to have no significant different between the groups. Mann Whitney U test P values were 0.327 and 0.727 respectively. See Table XV for the oral hygiene survey summary statistics.

Table XV. Oral Hygiene Survey Results

Oral Hygiene Survery	Wave (mean/SD)	Straight (mean/SD)	P-Value (ISMT)	P-Value (MWU)
Frequency of Brushing	2.72/0.510	2.66/0.592	**	0.727
Frequency of Flossing	1.08/0.929	0.51/0.702	0.083	0.006*
Retainer Comfort	2.15/1.014	1.89/1.157	0.583	0.327
Ease of Flossing	3.37/0.714	1.46/1.039	0.000*	0.000*

*Significance at 0.05 level.

** Unable to compute.

CHAPTER FIVE

DISCUSSION

The finding of statistical significance for both the PI on tooth numbers 23 and 33 and PPD on tooth 41 should be considered within the general context of the other data. Though statistically signficant p values were found for these teeth with regards to these specific measures, it would seem reasonable to conclude that these findings are not clinically signficant when considered in context.

However, some of the findings from the collected data were significant, specifically in regards to the reported frequency and ease of flossing with a WR. Fixed retainers are more difficult to floss around and one would expect self-reported frequencies of flossing and ease of flossing to be low with a retainer that complicates this proceure. Higher flossing frequencies would naturally be expected with a retainer design that minimizes oral hygiene complications such as the WR.

This assumption seems to be supported by the research data. Figure 3 shows the frequency of flossing by percent for each group. The WR group reported much higher frequencies of flossing than the SR group that could be attributed to the fact that the the WR is designed to make flossing easier.

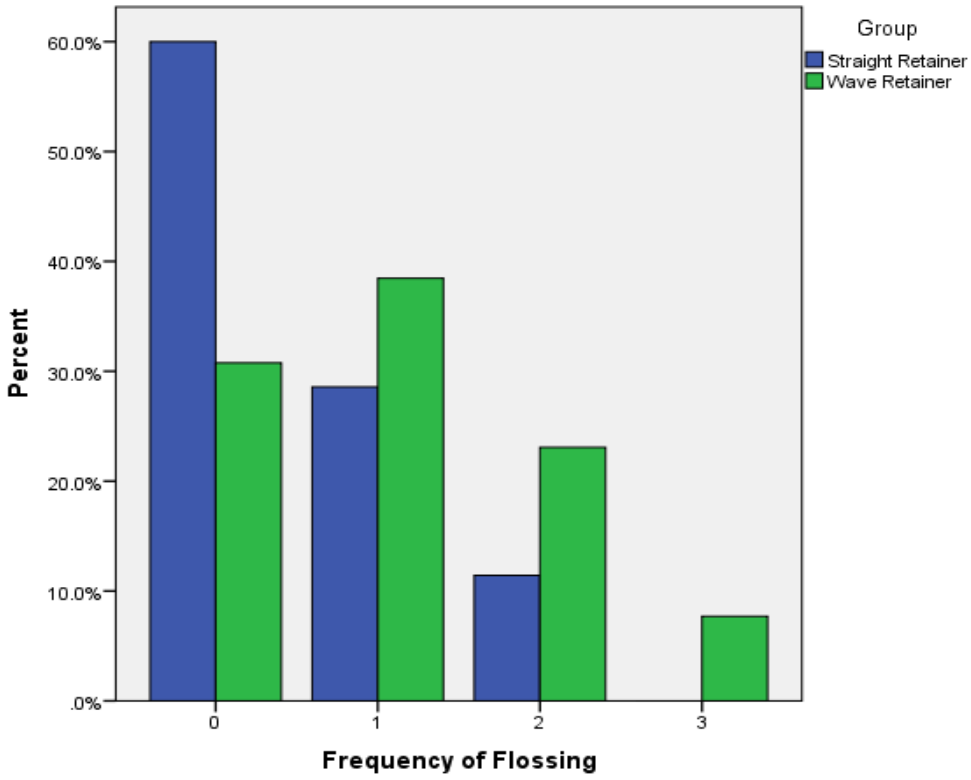

Fig 3. Percent Frequency of Flossing. 0= Never, 1= 2-3 times per week, 2= 1 time per day, 3= 2 or more times per day.

Figure 4 shows that the WR received much higher scores for ease of flossing as well. Flossing with the WR was consistently rated as easy or very easy. It would not seem unreasonable to conclude that as the ease with which one is able to floss increases so does the flossing frequency. Figure 4 shows the ease of flossing by percent within each group.

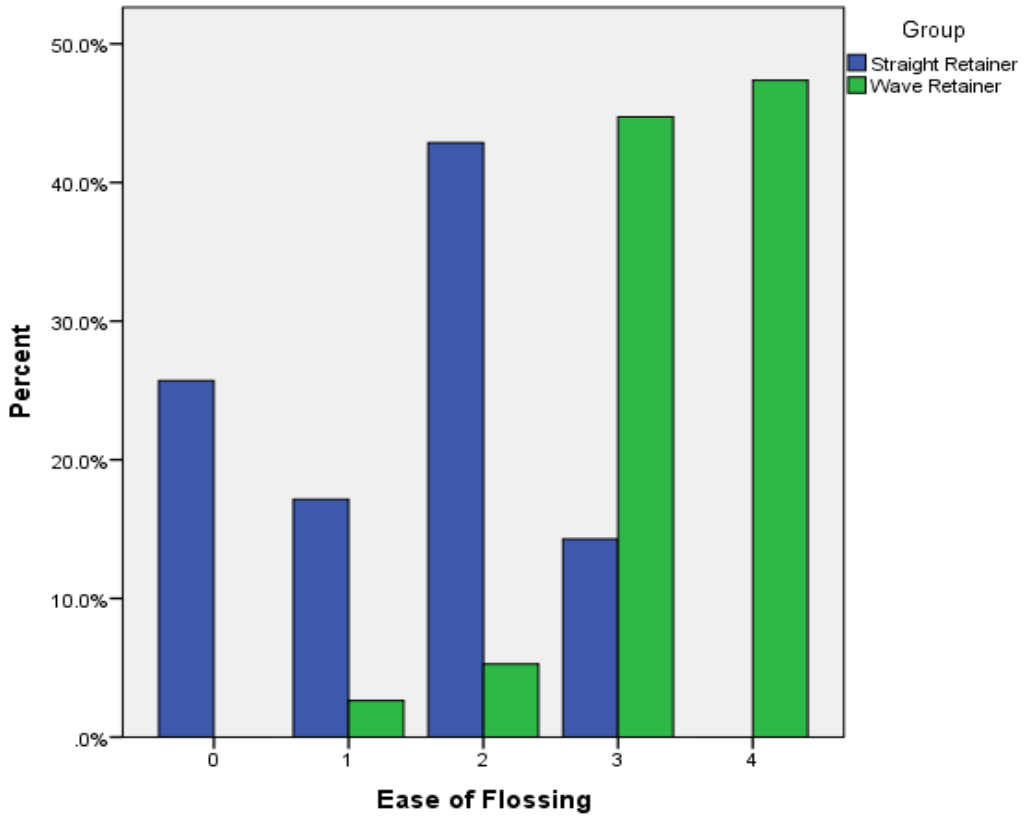

Fig 4. Percent Ease of Flossing. 0= Very difficult, 1= Difficult, 2= Somewhat difficult, 3= Easy, 4= Very easy

According to this data, approximately 90% of sujects with a WR found flossing to be relatively easy, compared to about 15% with a SR. Put another way, roughly 90% of subjects with a SR retainer found some level of difficulty associated with flossing. See figure 5 for a bar graph of ease of flossing and Appendix E for summary data.

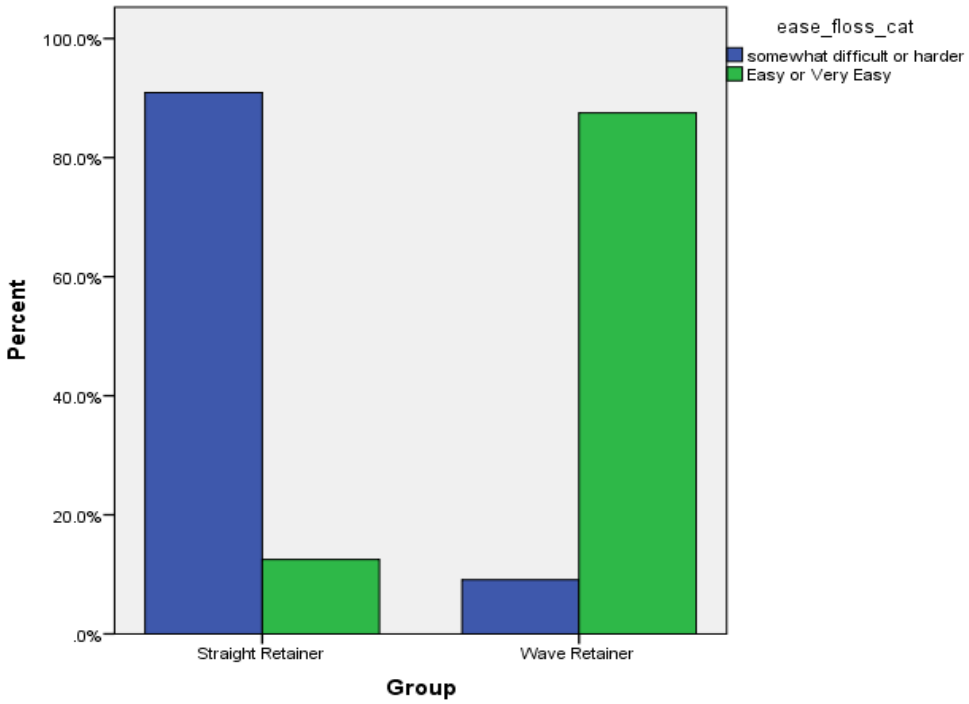

Fig 5. Ease of Flossing

It is interesting to note that for the retention times evaluated in this study, the frequency of flossing, though significanlty different between the groups, did not appear to make a significant difference in the periodontal health findings associated with the teeth bonded to the fixed retainer. Since frequency of brushing was essentially the same for both groups (Appendix G) one could reasonably expect the frequency of flossing to postively impact the periodontal health in the wave retainer group. This difference either was not captured in the data or does not exist for this group at these retention times.

Some support for this result can be found in 2 systematic reviews done in 2008 and 2011 respectively. The 2008 review concluded that routine instruction to use floss is not supported by scientific evidence.[24] The 2011 systematic review concluded that there was

some evidence that flossing in addition to toothbrushing reduces gingivitis compared to simply brushing alone and there was also weak, unreliable evidence that flossing plus brushing may be associated with a small reduction in plaque at 1 and 3 months.[25]

The question of whether or not flossing more frequently over a longer period of time (maybe 10 to 15 years or longer) would make a difference in periodontal health needs to be considered. Perhaps the period of retention was too short to be able to determine if there really was a difference. It is also possible that an older population may have yielded detectable differences given the same retention times.

In a study by Payne et al. it was found that 96% of survey respondents brushed daily, compared to 22% for flossing.[26] In this retainer study, there were approximately 31% of subjects with a WR retainer that flossed at least daily and only 11% of subjects with a SR flossed daily. Based on this information it would seem that subjects with a WR generally floss more frequently than the general public and those with a SR may floss less frequently. However, for the WR group the additional frequency of flossing does not appear to provide any additional benefit in their periodontal health.

One of the potential drawbacks to the WR could be the comfort or perceived comfort of such a retainer as compared to a SR. The WR requires a greater length of wire and the its position could reduce the perceived comfort by the patient. The data collected in this study demonstrated that subjects found both retainers equal in comfort. The gingival loops and added length of wire of the WR do not appear to bother patients (Fig 6).

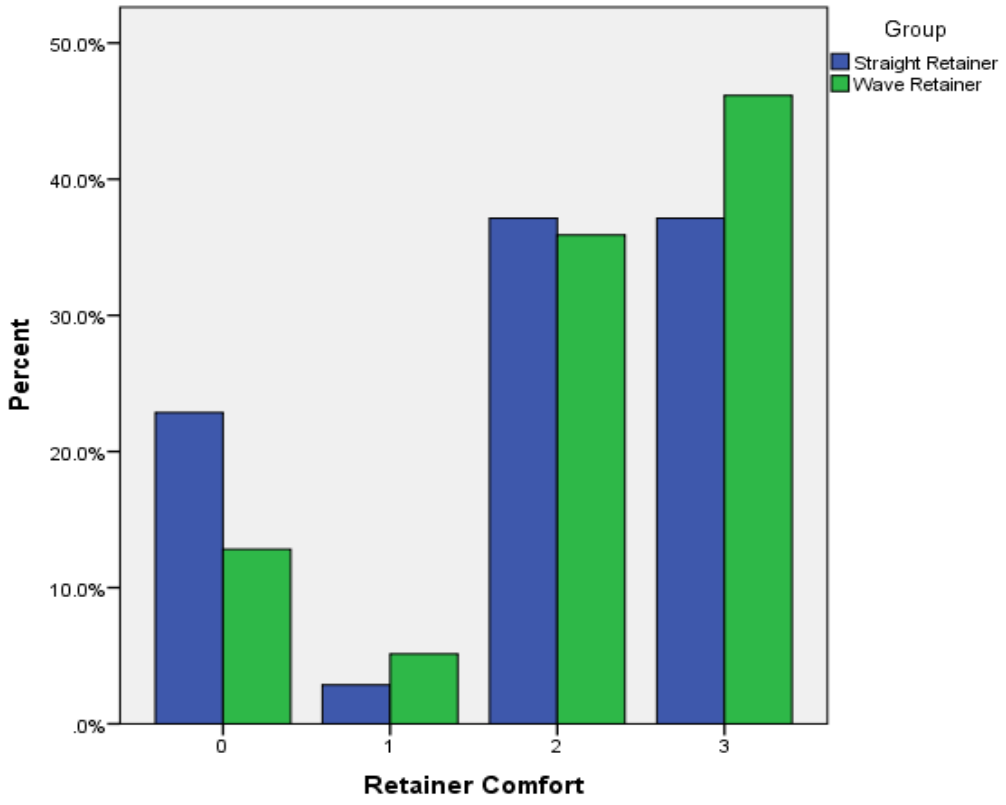

Fig 6. Percent Comfort of Retainer. 0= Very uncomfortable, 1= Somewhat comfortable, 2= Comfortable, 3= Very comfortable

The WR retainer was designed to allow for normal flossing technique. However, a close examination of the position of the gingival loops indicatd that they were still not apical enough to allow for flossing to the depth of the sulcus. It appeared that patients with this retainer can only floss to about the gingival margin or perhaps slightly below the margin, but would need to thread the floss under the retainer to floss into the depth of the gingival sulcus as is possible with normal flossing. This indicated that even though the majority of a tooth's surface can be flossed with normal technique, it may not be possible to floss the entire interproximal surface. Potentially the most important area, that of the gingival sulcus, cannot be flossed with the WR. This issue could account for

the lack of significant differences in periodontal health between the two groups.

In regards to age and retention time, the median and distribution analysis of the study data indicated a significant difference between the two groups. However, this difference did not appear to have a significant effect on the results of the study. Though the WR group tended to be younger and generally had shorter retention times than the SR group, there was no evidence that this influenced the research findings. This seems to indicate that within the age range selected for this study, age and gender did not appear to significantly alter the outcomes of the periodontal health markers evaluated. Perhaps one would have to study an older population before age and gender would influence research findings.

There seems to be one main advantage in the design of the WR as proposed and that is to make flossing easier and thereby increase the frequency of patients flossing and improve their periodontal health. This study supports the idea that making flossing easier will increase the number of patients who floss, but it does not support the assumption that this increased frequency of flossing will improve their periodontal health.

In addition, this study also does not appear to support the premise that a fixed retainer placed closer to the gingival tissue will increase gingival and periodontal inflammation and the associated sequelae.

Study Improvements and New Directions

In a cross-sectional study such as this one, increasing the sample size and the retention time could be helpful in improving the reliability of the study outcomes and lend more credibility to the initial findings of this pilot study. Another approach could be

to conduct a randomized controlled study where subjects with either a removable, SR or WR were evaluated over a given time period to evaluate whether the periodontal health of the teeth is significantly different among the various retention options available.

The bleeding on probing score for this study was recorded as a "yes" or "no" regardless of the amount of bleeding present. At times blood would instantly well up in the sulcus after a probing measurement was made and at other times there was merely a very small point of blood that appeared after many seconds had passed. Each of these scenarios received the same score, though clinically there was a significant difference in the observed result. As designed, the study did not provide a way to differentiate or quantify these various findings. An improvement for future studies of this nature would be to devise a scale such as mild, moderate or severe to better define the level of bleeding associated with the gingival tissue. With such a scale in place there might be measurable, significant differences noted in bleeding that is typically considered an important sign of gingival inflammation.

Future areas of research could include comparisons of breakage and stability of retention between the SR and WR. If periodontal health is similar between the two it could be that these other considerations could make the WR a better treatement option even though the cost is higher and placement is more technique sensitive. It seems quite common to have breakage of a maxillary fixed cuspid to cuspid retainer between the lateral and canine where the lower canine occludes with the upper dentition. With a WR this problem appears to be less of a problem as the interdental scallop lowers the wire away from the plane of occlusion and could potentially result in less breakage.

CHAPTER SIX

CONCLUSIONS

Under the conditions of this study, the results indicated that there was no significant difference in the periodontal health of anterior teeth retained with either a straight or wave fixed retainer. However, there was a significant difference in the self-reported frequency and ease of flossing between the subjects. Subjects with a wave retainer reported higher frequencies and greater easy of flossing.

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APPENDIX A

ORAL HYGIENE QUESTIONNAIRE

Please Circle One (1) of the following responses for each question.

1. Do you brush your teeth and if so, how often?

a. Never
b. 2-3 times/week
c. 1 time/day
d. 2 or more times/day

2. Do you floss your teeth and if so, how often?

a. Never
b. 2-3 times/week
c. 1 time/day
d. 2 or more times/day

3. Which type of interdental cleaning aid do you use, if any?

a. None
b. Regular floss
c. Superfloss
d. Water pick
e. Floss threader
f. Tooth pick
g. Other: _____

4. Do you use mouth rinse and if so, how often?

a. Never
b. 2-3 times/week
c. 1 time/day
d. 2 or more times/day

5. What brand do you use?

a. Crest
b. Scope
c. Listerine
d. Other: _____

6. How would you rate the comfort of your fixed retainers?

a. Very Uncomfortable
b. Somewhat uncomfortable
c. Comfortable
d. Very comfortable

7. How easy or difficult is it to floss your front teeth with your fixed retainers in place?

a. Very difficult
b. Difficult
c. Somewhat difficult
d. Easy
e. Very Easy

8. How long does it take to floss and brush your front teeth?

a. 0-30 seconds
b. 30-60 seconds
c. 1-2 minutes
d. More than 2 minutes

9. When was the last time you brushed your teeth?

a. Less than 4 hours ago
b. More than 4 hours ago

10. When was the last time you flossed your teeth?

a. Less than 4 hours ago
b. More than 4 hours ago

Name: _____ Date: _____

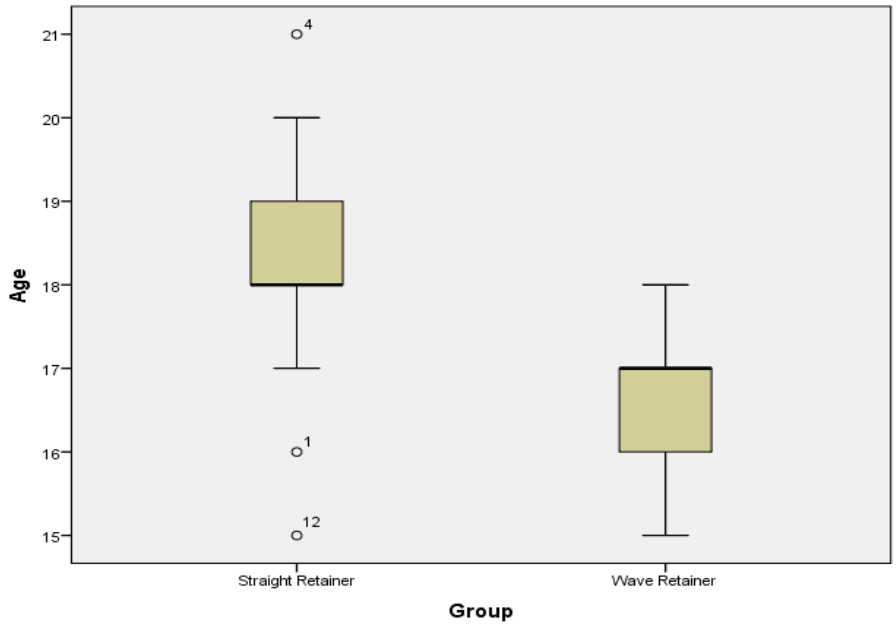
APPENDIX B

SUMMARY OF DEMOGRAPHIC DATA

Group		Age(years)	Retention Time(months)	Sample #	Gender
Straight Retainer				35	
	Male				17
	Female				18
	Mean	18.3	42.3		
	Std. Dev.	1.3	2.4		
	Min.	15	39		
	Max.	21	48		
Wave Retainer				39	
	Male				13
	Female				26
	Mean	16.9	31.6		
	Std. Dev.	0.96	3.2		
	Min.	15	24		
	Max.	19	42		

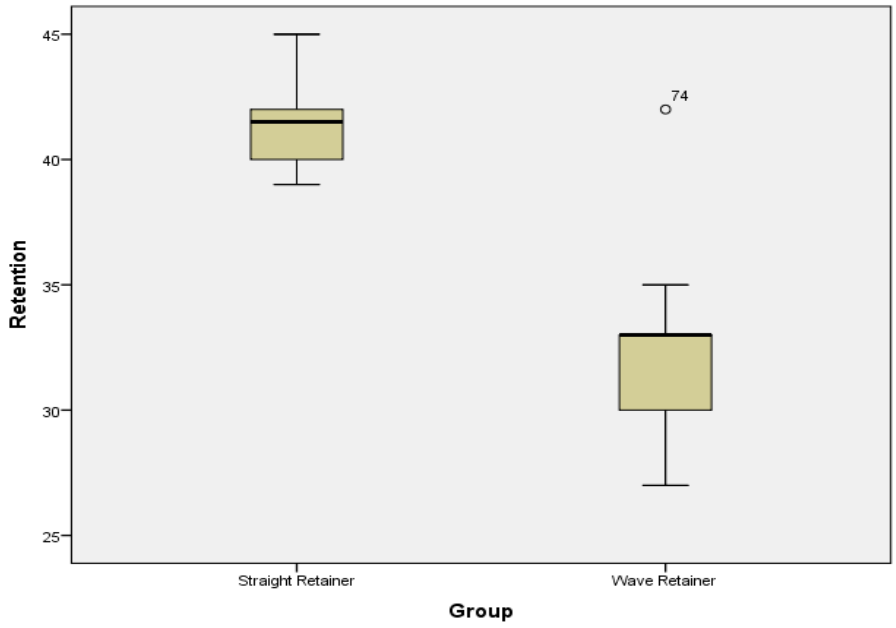
APPENDIX C

BOX PLOT OF AGE IN YEARS



APPENDIX D

BOX PLOT OF RENTION IN MONTHS



APPENDIX E

FREQUENCY OF FLOSSING

Frequency of Flossing						
Group			Frequency	Percent	Valid Percent	Cumulative Percent
Straight Retainer	Valid	0	21	60.0	60.0	60.0
		1	10	28.6	28.6	88.6
		2	4	11.4	11.4	100.0
		Total	35	100.0	100.0	
Wave Retainer	Valid	0	12	30.8	30.8	30.8
		1	15	38.5	38.5	69.2
		2	9	23.1	23.1	92.3
		3	3	7.7	7.7	100.0
		Total	39	100.0	100.0	

APPENDIX F

EASE OF FLOSSING

Ease of Flossing						
Group			Frequency	Percent	Valid Percent	Cumulative Percent
Straight Retainer	Valid	0	9	25.7	25.7	25.7
		1	6	17.1	17.1	42.9
		2	15	42.9	42.9	85.7
		3	5	14.3	14.3	100.0
		Total	35	100.0	100.0	
Wave Retainer	Valid	1	1	2.6	2.6	2.6
		2	2	5.1	5.3	7.9
		3	17	43.6	44.7	52.6
		4	18	46.2	47.4	100.0
		Total	38	97.4	100.0	
	Missing	System	1	2.6		
	Total		39	100.0		

APPENDIX G

FREQUENCY OF BRUSHING