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Interproximal reducation in conjunction with plastic aligner therapy : a retrospective pilot study.

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INTERPROXIMAL REDUCTION IN CONJUNCTION WITH PLASTIC ALIGNER THERAPY: A RETROSPECTIVE PILOT STUDY

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A Thesis Approved on

August 5, 2011

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DEDICATION

This thesis is dedicated to family as a testament to their never ending support for what has probably felt like never ending schooling on my part. To my wife Marie, thank you for your love and support; I could not do it without you. To my son Weston, you have been the joy in our lives.

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I would like to thank all of my committee members, Dr. Sunita Chandiramani, Dr. David Tasman and Dr. Eric Bednar for their help in guiding me through this study, especially when I have hit bumps in the road. I would also like to acknowledge Alex Cambon for his work and help in analyzing this data for this project.

ABSTRACT

INTERPROXIMAL REDUCTION IN CONJUNCTION WITH PLASTIC ALIGNER THERAPY: A RETROSPECTIVE PILOT STUDY

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August 1, 2011

Background: For more than 10 years, Invisalign has been a treatment alternative to traditional bands and brackets for the treatment of malocclusion. In order to relieve crowding in the dentition, interproximal reduction (IPR) or stripping is often required. Invisalign dictates how much IPR should be done per case. **Hypothesis:** The hypothesis is that less tooth structure is removed by IPR during treatment than is advocated by Invisalign. **Methods:** Subjects will be patients from the University of Louisville who were treated with Invisalign. The mesial-distal width of the teeth on pre and post treatment models will be measured and compared against the amount of IPR that was recommended by Invisalign. **Results**: 6 subjects with 130 teeth treated met the inclusion criteria. Of those 130 teeth, 33 were subject to IPR. The mean amount of IPR was within .02mm of the expected amount of IPR as set forth by Invisalign.

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CHAPTER I

INTRODUCTION

A. Introduction

Traditionally, orthodontic treatment has been accomplished by bonding fixed appliances directly to the teeth. In 1999, Align Technology, Inc. (San Jose, CA, USA) formed and provided a removable alternative to fixed appliance therapy. Marketed under the tradename Invisalign, Align employs 3-dimensional graphic modeling, computer-aided design (CAD) and computer aided modeling (CAM) to manufacture a series of stereolithographic (SLA) models from which clear polyurethane resin trays are fabricated. The customized trays are to be worn sequentially in treatment until the treatment objectives are reached. Each tray is designed to yield approximately 0.2mm of translation and 1 degree rotation per tooth. When addressing the problem of crowding in malocclusions, several approaches can be used to gain the necessary space to align the teeth. If crowding is minimal, teeth can be flared facially to gain the required space. When crowding is beyond minimal, tooth structure must be removed in order to make enough room for alignment of the teeth. This can be accomplished by two different methods. Teeth, such as 4 premolars, can be extracted to relieve the crowding. If it is undesirable to extract teeth, tooth size can be reduced on individual teeth by interproximal reduction (IPR). The width of teeth can be

reduced in a mesiodistal direction by several methods involving the removal of enamel from the interproximal surface. It has been reported in the literature that up to 1mm of enamel can be removed per contact area between teeth. Most Invisalign cases utilize IPR to make room for all the teeth. At the start of treatment, Align tells the practitioner where to do IPR and how much tooth structure to remove. Due to the nature of some malocclusions, it is not always possible to measure how much IPR is actually done on the patient.

B. Literature Review

Invisalign

Traditionally, orthodontic treatment has been accomplished by bonding fixed appliances directly to the teeth. Although Align Technology, Inc. (San Jose, CA, USA) has been manufacturing removable orthodontic appliances for over 10 years, the concept of removable appliances is far from new. The earliest noted used of a removable appliance was in 1836 when Friedrich Christoph Kneisel (1979-1847, German) delivered a chin strap to his patient, Prince Charles of Prussia. He and John Tomes (1812-1895, English) used various Removables such as plates with wires to move teeth.[1] Many removable appliances were introduced to the field of orthodontics over the next 100 years although all were functional appliances. It wasn't until the mid-twentieth century that a removable appliance was invented for the primary purpose of straightening teeth. In 1944, Harold D. Kesling (1901-79) developed the tooth positioner. The

technique involved taking impressions of a patient nearing completion, denuding the plaster of appliances, and resetting the teeth into ideal positions (the "diagnostic setup"). From the new models, a rubber positioner was made that, if worn enough hours, acted as a finishing appliance.[2] It could also be used as a retainer or a recovery appliance. Out of these innovations developed T(ooth) P(ositioner) Orthodontics (LaPorte, Ind), a company that still sells orthodontic products and services today.[3,4] This system, while innovative, proved to be too cumbersome to effect any significant tooth movements. Others, in later years, developed clear plastic aligners which could be used to effect tooth movement. Perhaps the most well known was the technique developed by Raintree Essix (New Orleans, LA). This technique uses clear aligners formed on plaster models of the teeth. The aligners are then modified with "divots," which create a force to push on the individual teeth, and "windows," which create the space for teeth to move into. This type of appliance can be effective in correcting mild discrepancies in the alignment of teeth. However, movements are limited to 2 to 3 mm; beyond this range, another impression and a new appliance are needed.

Align Technology, Inc. (San Jose, CA, USA) formed in 1997 and has provided a removable aligner alternative to fixed appliances in correcting malocclusion since 1999. In a landmark paper, Wong (2002)[5] provided a step by step overview of how Invisalign works from initial records through completion of treatment. Patient records are taken which consist of polyvinyl siloxane (PVS) impressions of both arches, a centric bite, a standard set of clinical photographs, a panoramic image,

and a lateral cephalogram. The orthodontist then fills out a prescription form explaining the goals for the case and how they want to accomplish tooth movement. The prescription, along with all of the patient records, are submitted via mail or electronically to Invisalign where the impressions are, "poured up in dental plaster and then placed in a tray and encased with epoxy and urethane. The tray is placed into a destructive scanner; the scanner's rotating blade makes numerous passes over the epoxy-encased models, removing a thin layer with each pass. A computer linked with the scanner then assembles the scanned information to create a 3-dimensional rendering of the models. After the bite has been established, the Invisalign virtual orthodontic technician (VOT) uses software to "cut" the virtual models and separate the teeth, allowing them to be moved individually. A virtual gingiva is placed along the gingival line of the clinical crown to serve as the margin for the manufacturing of the aligners."[5] Once the orthodontist approves the treatment plan, the aligners are then manufactured by Align. The computer images are converted to a series of sequential stereolithographic models on which aligners can then be fabricated using a Biostar pressure molding machine (Great Lakes Orthodontic Products, Tonawanda, NY). In 2003, Kuo[6] expanded on Wong's review and clarified some beneficial changes to the scanning process. With laser scanning, direct line of sight of all surfaces is necessary for accuracy so a plaster model must still be fabricated. "In a CT scan, a series of digital radiographs of the object is captured, and the images are electronically processed to generate an extremely detailed 3-dimensional reproduction of the object. The scanner can

scan both stone models and impressions (if the tray is not steel or other high-density material), because any undercuts are completely visible to the scanner. Many objects can be scanned at once for maximum efficiency. PVS bite registrations can also be scanned. CT impression scanning is the preferred method because of its speed and accuracy. To create a virtual dental model directly from the impression with CT scanning, the impression is mounted on a platform that rotates in front of an amorphous silicon x-ray sensor (HYTEC, Inc, Los Alamos, NM). Hundreds of digital radiographs of the impression are captured as it rotates 360°. These radiographs are converted to images called sinograms which represent the data from a horizontal line of the detector as the part rotates. A 16 central-processing-unit fiber-optically linked computing cluster uses the sinograms and a series of mathematical algorithms to create 116-micron thick reconstruction slices of the object. These slices are stacked electronically and inverted, and the resulting surface is smoothed to yield a raw electronic study model."[6] From these electronic study models, stereolithographic models can be fabricated as with laser scanning. Once the aligners are fabricated, they are to be worn 20 to 22 hours a day for 1-2 weeks per aligner.

As with any new treatment modality, initial recommendations for what cases could be treated with Invisalign were conservative. Boyd et al. (2000)[7] were among the first to give treatment recommendations. They recommended only adults with fully erupted teeth and either mild crowding or spacing be treated with Invisalign. Since that time, more complex case reports have been cited in the

literature. Womack reported a case of 4 bicuspid extraction being treated with Invisalgin in 2006. In 2010, Shupp et al reported closing an anterior open bite with Invisalign. There have been case reports of Class II correction, deep bite correction, Class III correction, and even surgical orthognathic correction all with Invisalign. Clearly Invisalign has progressed in the types of treatment practitioners feel comfortable prescribing it for.

Interproximal Reduction

The correction of crowding in the dental arches is one of the oldest problems in orthodontics. The earliest known published treatment for crowding was by Pierre Fauchard (1678-1761) in his *The Surgeon Dentist: A Treatise on the Teeth* where he recommended the extracting of deciduous molars to relieve crowding. Since that time, orthodontists have debated the merits of extraction as a treatment modality for crowding. One of the first instances in the literature where IPR was first recommended to gain space was by Lusterman in 1954. In his paper, he described a case report of a Class II, Division II patient who was treated with standard fixed appliances of the time and with mesiodistal reduction of the mandibular teeth. Although the technique was not described in this case report, it did note that the clinician felt that the teeth were too wide and between the 4 incisors, a total of 3mm of stripping was done during treatment. It was also during this time that Begg came out with his theory about the etiology of modern malocclusion. Begg's theory was that primitive humans had a coarse diet that

led to attrition of the teeth and reduction in mesiodistal width. Modern man has a much softer diet and therefore, wider teeth which leads to crowding. A few years later in 1956, Hudson wrote a paper specifically about mesiodistal reduction of mandibular anterior teeth. In his paper, he reviewed the literature to that point in time, which had little documentation of stripping, and he made recommendations on the technique and amount of reduction that can be done. The technique for IPR included reducing the interproximal surfaces with either abrasive strips or disks. He also raised the question about whether enamel surfaces are more susceptible to caries after IPR. In a thesis by Wickwire, the author found a significant difference in the rate of decalcification in lactate buffer of stripped enamel when compared to the unstripped enamel from the opposite surface of the same tooth. The procedure for stripping was similar to that used to remove enamel by orthodontists. She concluded that the technique of stripping enamel for orthodontic purposes may predispose the tooth structure to a more rapid decalcification (that is, caries susceptibility) because of the interruption in the continuity of the enamel surface. Because of the concern for increased caries susceptibility of stripped surfaces, Rogers investigated the application of topical fluoride on stripped enamel surfaces. He found that enamel treated with a single application of fluoride had a significantly lower rate of decalcification for the first 96 hours compared with untreated enamel. Paskow recommended IPR not only to aid in the alignment of the mandibular incisors during treatment, but also as needed in retention to keep them aligned. Paskow was so enthusiastic about IPR that he suggested that given the right case selection, IPR could be done

without the need for fixed or removable appliances to align teeth. Boese was also a proponent of IPR for maintenance of mandibular incisor alignment post orthodontic treatment. He looked at 40 patients 4-9 years after treatment with no lower retention beyond reproximation within the first 6 months after debanding. The cases received on average 1.69mm of reduction during the first 6 months after appliance removal. The average irregularity according to Little's irregularity index after 4-9 years was only .62 showing that they were very stable. In 1985, Sheridan outlined a protocol for air-rotor stripping or ARS. He claimed that in lieu of extractions, stripping in the posterior could eliminate most crowding problems. He suggested that 50% of the interproximal enamel could safely be taken away giving the clinician a possible 8.9mm of space total within the arch. His technique proposed placing a.020" brass wire under the contact to protect the interdental tissues and serve as a guide and to use a 699L or small tapered bur for enamel reduction. Two years later, he published an update to his technique. The update suggested aligning the teeth first and then reproximating the distal most contact first, then add an open coil spring to the next contact to the mesial. This would distalize the mesially stripped tooth and in turn open the next contact which could then be reduced and the whole process repeated as needed. In 1994, Twesme sought to evaluate the effects of air-rotor stripping on the susceptibility of human enamel to demineralization using an in vitro caries model. This in vitro study showed that air rotor stripping increases the susceptibility of human proximal enamel to demineralization due to rough grooves. Short-term use of a fluoridated dentifrice or topical gel reduced penetration of the lesion but

not to the extent of a nontreated, unabraded surface. They recommended exercising caution when choosing to employ ARS. Harfin added that after stripping, all stripped surfaces must be polished with special composite polishing strips in a dry field. This would smooth out the stripped surface rendering it less plaque adhesive. Lucchese assessed surface changes in enamel caused by treatment with various stripping and finishing burs. He found that the technique producing the least roughness involved the use of a tungsten carbide bur to strip interproximal enamel, followed by finishing with medium, fine, and superfine Sof-Lex discs. Although many clinicians have shown that reduced enamel is rougher and more susceptible, numerous authors have shown that there is no increased risk for caries in the long term. Sheridan found that 2 to 5 years out, reduced teeth had no more incidence of caries than unreduced teeth in the same mouth. Zachrisson also found that 5 years out, there was no increased risk of caries in the posterior dentition after ARS. Looking even further out, he also found that 10 years out, there was no increased risk for caries or periodontal disease in manibular anterior teeth that had IPR.

C. Significance:

There is no current literature on the use of IPR in conjunction with Invisalign. With traditional fixed appliances, clinicians can do as little or as much IPR as they need to based on clinical observation. With Invisalign, the ability to modify how much IPR can or needs to be done is removed from the clinician's options during treatment. Because Invisalign predetermines how much IPR needs to be

done, the clinician must follow that protocol for the best fit of the aligners. Because IPR involves the removal of permanent tooth structure, it is always better to err on the side of being too conservative as more tooth structure can always be taken away later in treatment. There is no current literature showing how much IPR is done during average cases and whether the clinician removes more or less tooth structure than recommended by Invisialign.

D. Purpose:

This study has the following specific aims:

- To demonstrate that teeth that have IPR have a measurably reduced mesial distal width post Invisalign treatment.
- To determine if more or less tooth structure is removed than advocated by Invisalign.

E. Hypotheses:

Null hypotheses:

1. There is no measurable difference in the mesial distal width between teeth that had IPR and teeth that did not have IPR post Invisalign treatment.
2. The amount of IPR done during treatment will be the amount advised by Invisalign during treatment.

Alternative hypotheses:

1. There is a measurable difference in the mesial distal width between teeth that had IPR and teeth that did not have IPR post Invisalign treatment.

2. The amount of IPR done during treatment will be more or less than the amount advised by Invisalign during treatment.

CHAPTER II

METHODS AND MATERIALS

A. Sample:

The institutional review board of the University of Louisville reviewed and approved the study before chart review began. Approval was granted February 28, 2011 and given a tracking number of 11.0059. Any traceable patient identifiers were removed from the recorded data before data analysis.

B. Inclusion/Exclusion criteria:

To be included in this study, subjects must have met the following conditions:

1. Subject must have been a patient at the University of Louisville orthodontic clinic treated with Invisalign.
2. Both pre and post treatment plaster study models must be available for measuring the mesial distal width of the teeth.

According to the University account with Invisalign, 79 patients had completed treatment with Invisalign as of March 1, 2011. Every effort was then made to procure the study models from the patient records. Of the 79 initial subjects, only 6 had both pre and post treatment plaster models available.

C. Data collection:

The plaster models for each subject were evaluated both pre and post treatment. While wearing loupes (Orascoptic, Middleton, WI), the mesiodistal width of each tooth was measured with Cen-Tech digital calipers (Harbor Freight, Calabasas, CA). Pretreatment casts were measured for each subject first, followed by measurements of the post treatment casts. All data was recorded to the .01mm level in an excel spreadsheet. After the measurements were recorded, the amount of IPR requested by Invisalign was entered into the excel spreadsheet as a function of the expected difference between pre and post treatment tooth widths. If no IPR was required, the expected difference between pre and post treatment was 0mm. Expected differences were compared with the actual measured differences for statistical analysis. One week after data collection, one random subject was measured again to check for operator reliability.

D. Statistical analysis:

Descriptive statistics are given in Table 1. A two sided t-test for unequal variances was used to determine the significance of the actual difference between the teeth that had IPR and those that did not. A one sample t-test was used to compare expected difference vs. the actual difference for the IPR group to determine if more or less tooth structure was taken away than prescribed. Lin's concordance correlation coefficient was calculated for the one subject who was measured at different times to check for operator reliability.

CHAPTER III

RESULTS

6 total subjects met all the inclusion/exclusion criteria. 4 of the 6 subjects had IPR during treatment. The 6 subjects had a total of 130 teeth which were measured. Of those 130 teeth, 97 had no IPR during treatment and 33 had IPR during treatment. The following descriptive statistics are given in Table 1:

1) Mean, standard deviations, medians, minimums, maximums, 5% and 95 % quartiles of actual and expected differences for teeth that had IPR .
2) Mean, standard deviations, medians, minimums, maximums, 5% and 95 % quartiles of actual differences for teeth that had IPR .
3) Mean, standard deviations, medians, minimums, maximums, 5% and 95 % quartiles for differences between expected and actual measurements for teeth that had IPR and those that did not.

The teeth were measured in pre and post treatment widths. The post treatment widths were subtracted from the pretreatment widths and recorded as a difference. Because the pre treatment and post

treatment widths should be the same for non-IPR teeth, the expected difference for them should be 0. This serves as a control to compare with the IPR teeth. The expected difference for the IPR teeth was a mean of 0.24mm as shown in line 3 of Table 1.

Table 1: Distribution of Actual Measurements, Expected Measurements, and

							Quartiles		
Meas.	IPR	Mean	SD	Median	Min	Max	5%	95%	P
Actual	No	-0.0045	0.1088	-0.01	-0.33	0.29	-0.180	0.166	<0.0001*
Actual	Yes	0.2636	0.2163	0.20	-0.05	0.72	-0.004	0.678	
Expected	Yes	0.2424	0.1318	0.20	0.10	0.50	0.100	0.500	
Exp. - Act.	No	0.0045	0.1088	0.01	-0.29	0.33	-0.166	0.180	0.469**
Exp - Act.	Yes	-0.0212	0.1887	-0.01	-0.50	0.39	-0.234	0.260	

* p-value represents test of difference from 0 for teeth that had IPR and those that did not (top two rows). The p-value for difference from zero for teeth that had IPR is also <0.0001(not shown in table).

** p-value represents test of difference in differences (expected minus actual) for teeth that had IPR and those that did not.

For teeth which did not have the IPR, the mean of the measured (actual) difference was -0.005mm, 95% CI - (-0.026, 0.017) (line 1, Table 1). The p-value for testing for difference from 0 for these teeth was 0.682 (one-sample t-test). This is one test of the reliability of the before vs. after measurement, since the measurement for teeth which did not have IPR should be the same. It shows no statistical significancece of difference from zero. The green box plot in Figure 1 shows this graphically. It is centered very close to 0. For teeth which had IPR, the mean expected difference was 0.24mm (line 3, Table 1). The mean actual difference was 0.26mm (line 2, Table 1). The actual

difference was significantly different from 0 (p-value <0.0001). The mean actual difference between teeth that had IPR and those that did not was 0.268 mm (95% CI = -0.348, -0.189). The mean in the group that did not have IPR was -0.005mm, and it was 0.264mm in the group that did have IPR [this does not add up to the difference because of round-off error]. The difference was very significant (p-value <0.0001, two-sided t-test, unequal variances). The box plot (Figure 1) shows this difference between the two groups

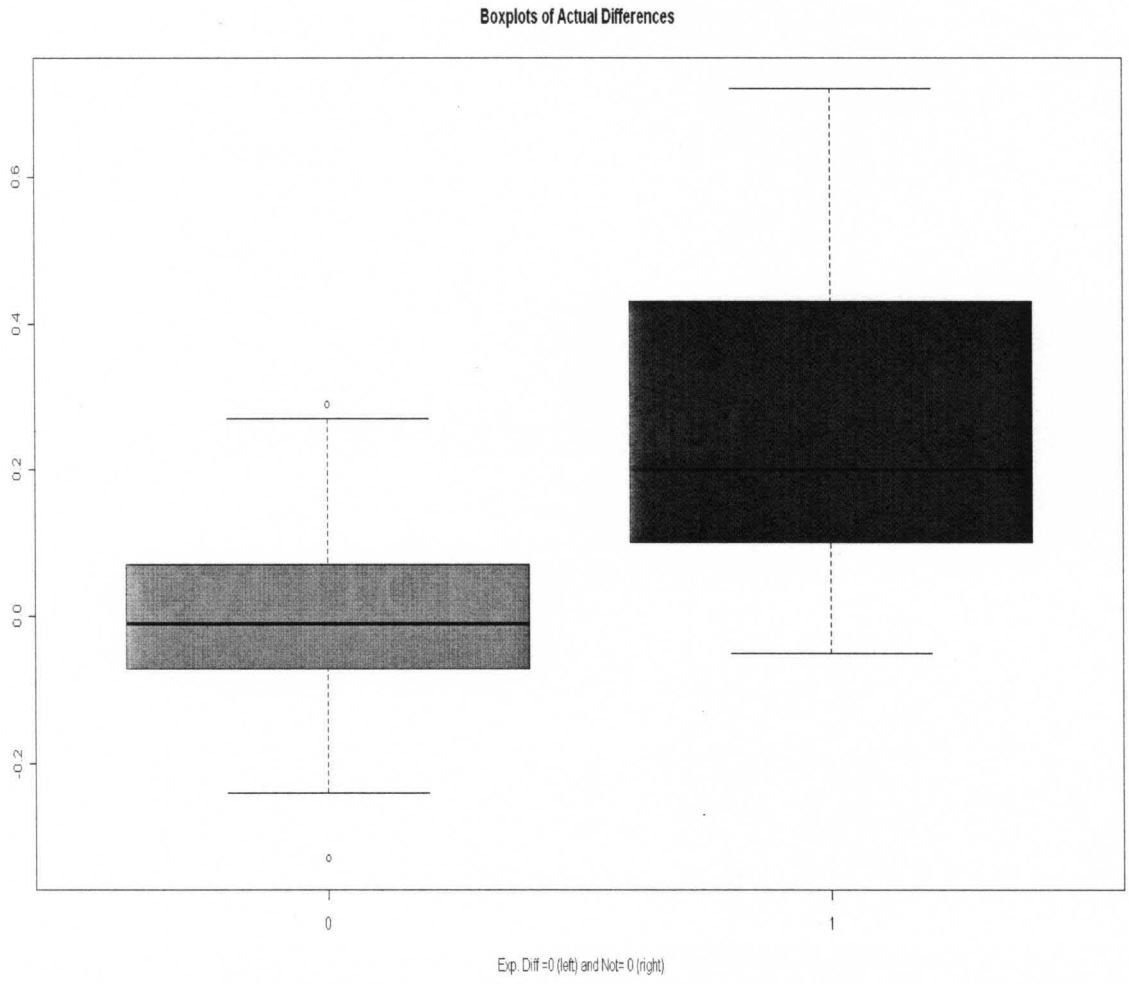

Figure 1: Non IPR and IPR group comparisons

. Figure 2 shows a histogram of the actual measurements for teeth which had IPR. For those teeth that had IPR, the mean difference between expected difference minus actual difference was -0.0212mm, (95% CI: -0.0881, 0.0457). This was not significantly different from 0 (p-value-0.523, one-sample t-test).

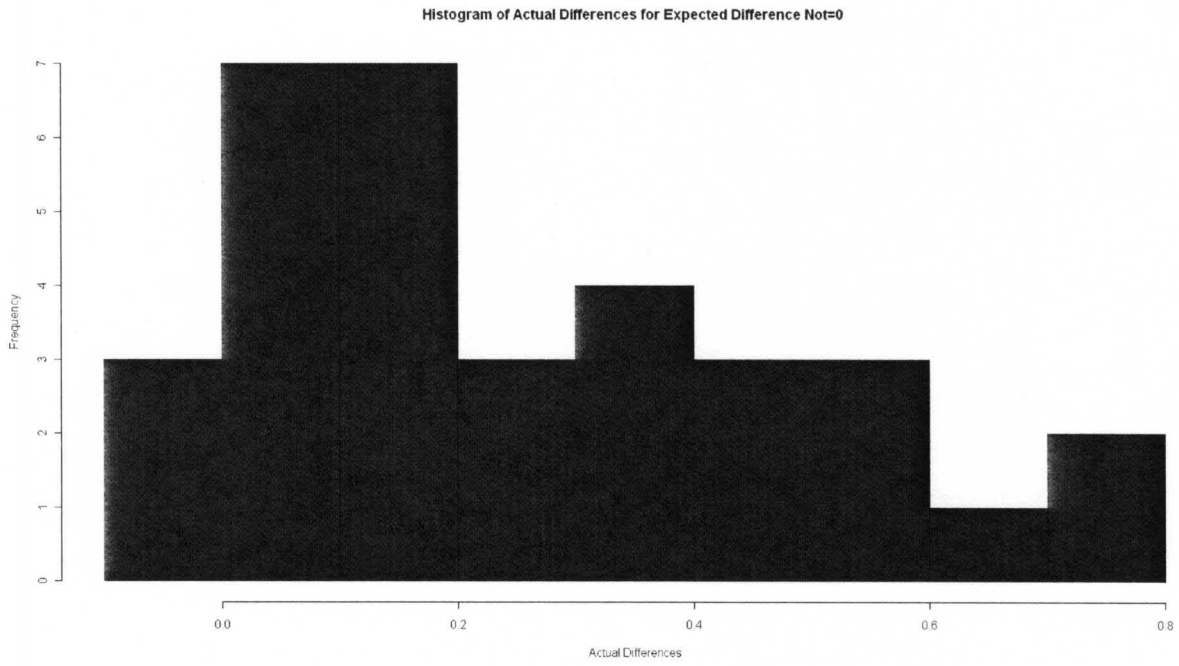

Figure 2: Histogram of actual differences for teeth that did have IPR

Line 4 in table 1 shows the expected difference minus the actual measured difference for the teeth that did not have IPR. The mean was 0.0045mm. Line 5 in table 1 shows the expected difference

minus the actual difference for the teeth that had IPR. The mean was -0.02. The comparison between these 2 numbers was yielded a p-value of 0.469. That means there was no statistically significant difference between the non-IPR and the IPR teeth. That means that both were within the expected norms that were expected. This suggests that in these subjects as much IPR was done as was expected.

Figure 3 shows box plots of actual minus expected differences for the all 6 subjects for teeth that had IPR. For the 2 subjects who had no IPR, no box plot is shown.

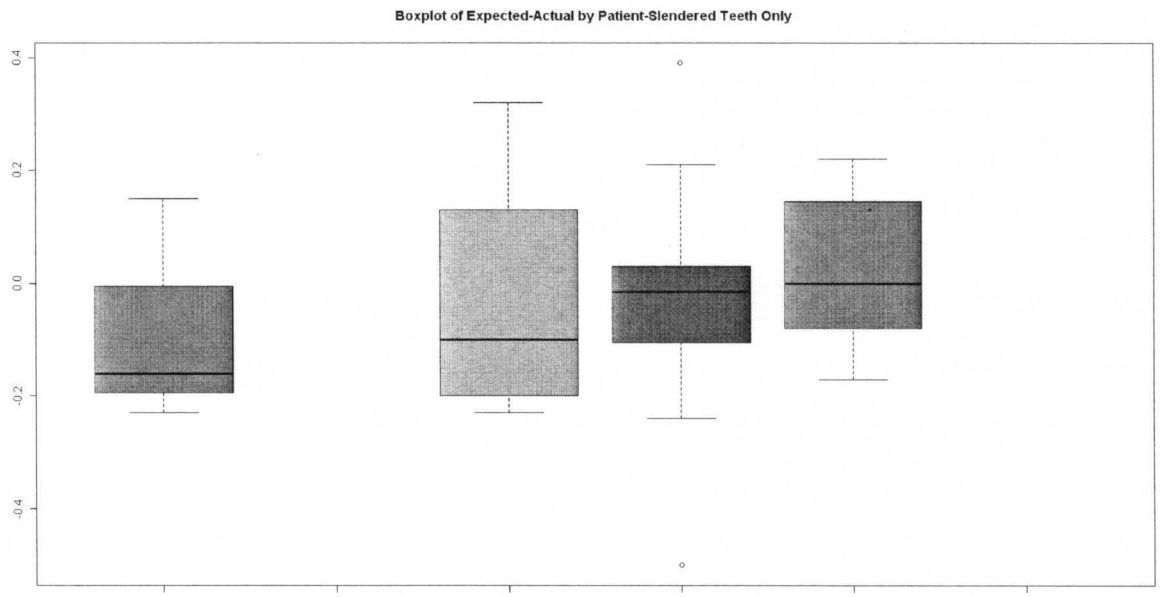

Figure 3: Box plots of expected minus actual differences by subject, for teeth that had IPR.

For comparison of measurements on subject 1 at two different time

points: (not differentiating between pre and post treatment measures): Lin's concordance correlation coefficient was 0.9995 (95% CI 0.9992, 0.9997). A value of 1 represents perfect concordance, and the value for these two time points is very close to that. The scatter plot (Figure 3) gives a visual representation of the concordance of the measurements at time 1 and time 2. The dark orange line has an intercept of 0 and a slope of 1. This is the line of perfect concordance. Paired measurements (Time 1 vs. Time 2) with perfect concordance correlation (of 1) would be represented with all points exactly on this line. As can be seen, all the measurements are extremely close to this line. The "bias correlation factor" is 0.9999998 (a value of 1 signifies no deviation from the 45 degree line – the line with slope 1). This is extremely reliable and can be seen visually by Figure 4 as well as by the Lin concordance correlation coefficient and related statistics.

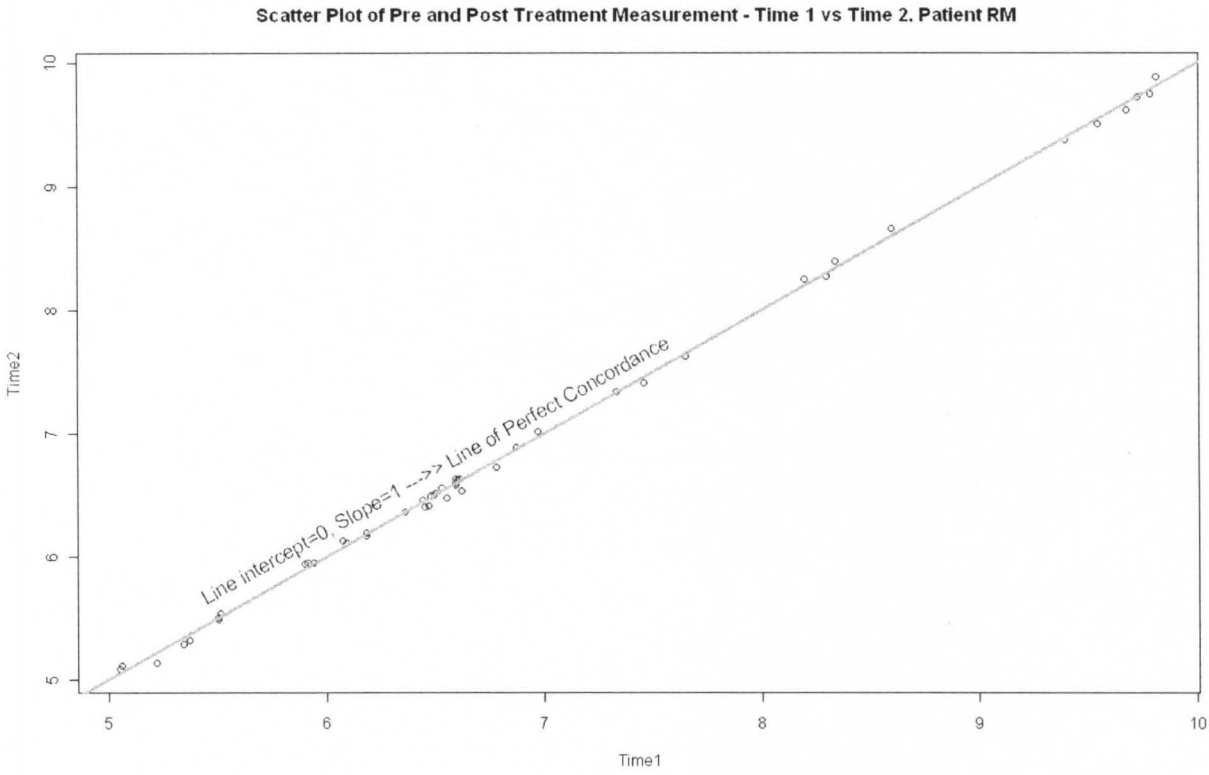

Figure 4: Scatter plot of measurements on subject 1 at two different time points. Orange line is line of perfect concordance (intercept =0, slope =1).

CHAPTER IV

DISCUSSION

Invisalign is a treatment modality where the practitioner loses some clinical autonomy due to the limitations of the having someone else do the virtual set-up for tooth movement. One of the areas where clinicians can lose autonomy is how much IPR needs to be done during a case. The results of this study showed that the teeth that were reproximated during treatment were smaller than comparable controls (p-value <0.0001). This study also showed that for those teeth that had IPR, there was not a significant difference from the amount prescribed by Invisalign (p-value-0.523). While the results of this study are not surprising, there are several shortcomings which could have influenced their outcome. Initially when this study was designed, it was expected that the sample size would be significantly larger. Of the 79 possible subjects who could have been used in this study, 73 were disqualified because either pre or post treatment plaster models or both were missing. While some records may have been lost, it is unlikely that all 73 records were misplaced. More diligent record taking is recommended in the future. Because of the small sample size, it is possible that trends in the larger patient population would not be seen. Another confounder is the number of clinicians who treated the patients. There were 5

clinicians who treated the 6 subjects. It is likely that there is some variation among clinicians as to how much enamel they tend to remove when doing IPR. Looking at Figure 3, the mean amount of expected difference minus actual difference among subjects varies significantly. The first subject has a mean difference of almost -0.2mm compared with other subjects where the mean was closer to zero. Is it because that one clinician is "heavy-handed" when doing IPR or is it more indicative of a larger trend that would have been borne out with a larger sample size? One way to improve the strength of this study would be to limit it to one or two treating clinicians so that variable could be removed. Another confounder is this study did not look at which individual teeth had IPR. If the sample was large enough, individual teeth could be looked at. It is possible that while overall there is no significant difference between expected and actual IPR, there could be a significant difference for certain teeth in the mouth such as mandibular incisors. While Lin's concordance correlation coefficient suggests the operator was consistent in measuring the mesidistal widths of the teeth for the one subject that was measured twice, it is still possible that operator error could have been introduced during measurements of the other casts.

CHAPTER V

CONCLUSIONS

A. Summary:

This aim of this study was to compare compare the actual amount of IPR with the prescribed amount of IPR in subjects who were treated with Invisalign. There was a statistically significant difference in pre and post treatment mesiodistal width between teeth that had IPR and teeth that did not have IPR. There was no statistically significant difference between the amount of IPR expected and the actual amount of IPR that occurred.

B. Conclusions:

This study sought to compare mesiodistal width in teeth that had IPR and teeth that did not have IPR in subjects that had Invisalign. This study also sought to quantify whether more or less IPR took place clinically compared with what Invisalign prescribed. While this study was able to conclusively demonstrate the first aim, the second aim did not prove conclusive. It is possible that the results of the second aim are true and that clinicians remove the exact amount of enamel required by enamel but there are several possible confounders to this result. Further study with a larger sample and one or two clinicians is warranted

to give more credence to this result. Regardless of the results, it is always prudent to use conservative clinical judgment when removing enamel during orthodontic treatment.

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Appendices

Appendix A: Data Entry Spreadsheet

Patient #	Tooth #	Pre tx Width	Post Tx width	Expected Difference	Actual Difference
1	3	9.68	9.55	0	0.13
	4	6.6	6.61	0	-0.01
	5	6.55	6.45	0.15	0.1
	6	7.65	7.33	0.25	0.32
	7	5.9	5.91	0.2	-0.01
	8	8.3	8.2	0.1	0.1
	9	8.6	8.34	0.25	0.26
	10	6.18	6.07	0.5	0.11
	11	7.46	6.97	0.4	0.49
	12	6.59	5.94	0.15	0.65
	13	6.49	6.48	0	0.01
	14	9.4	9.73	0	-0.33
	19	9.82	9.79	0	0.03
	20	6.78	6.87	0	-0.09
	21	6.47	6.59	0	-0.12
	22	6.18	6.09	0.1	0.09
	23	5.5	5.06	0.2	0.44
	24	5.37	5.05	0.2	0.32
	25	5.34	5.22	0.1	0.12
	26	5.51	5.5	0	0.01
	27	6.53	6.62	0	-0.09
	28	6.44	6.36	0	0.08
	29	6.59	6.5	0	0.09
	30	Missing			
2	3	10.7	10.88	0	-0.18
	4	6.73	6.91	0	-0.18
	5	7.06	6.82	0	0.24
	6	8.19	8.27	0	-0.08
	7	6.93	7.04	0	-0.11
	8	8.43	8.46	0	-0.03
	9	8.5	8.44	0	0.06
	11	8.29	8.18	0	0.11
	13	6.81	6.82	0	-0.01
	19	11.42	11.26	0	0.16
	21	7.07	7.23	0	-0.16
	23	6.4	6.4	0.15	0
	25	5.14	4.61	0.3	0.53
	27	7.25	6.94	0.15	0.31
	29	7.63	7.5	0	0.13

3	3	10.12	10.18	0	-0.06
	4	MISSING			
	5	6.59	6.5	0.25	0.09
	6	7.67	7.49	0.5	0.18
	7	6.14	5.42	0.5	0.72
	8	8.09	7.37	0.5	0.72
	9	8.09	7.51	0.4	0.58
	10	6.15	5.98	0.3	0.17
	11	7.94	7.43	0.4	0.51
	12	6.89	6.77	0.25	0.12
	13	MISSING			
	14	10.17	10.39	0	-0.22
	19	10.2	10.27	0	-0.07
	20	MISSING			
	21	6.73	6.86	0	-0.13
	22	6.86	6.77	0	0.09
	23	5.88	5.8	0	0.08
	24	4.63	4.68	0	-0.05
	25	4.8	4.88	0	-0.08
	26	5.45	5.25	0.1	0.2
	27	6.87	6.44	0.2	0.43
	28	6.89	6.86	0.1	0.03
	29	MISSING			
	30	10.29	10.32	0	-0.03
4	3	9.51	9.58	0	-0.07
	4	6.1	6.17	0	-0.07
	5	6.04	5.85	0	0.19
	6	7.33	7.43	0	-0.1
	7	5.83	5.92	0	-0.09
	8	8.21	8.12	0	0.09
	9	8.12	8.15	0	-0.03
	10	6.01	5.98	0	0.03
	11	7.39	7.3	0	0.09
	12	5.93	5.94	0	-0.01
	13	6.48	6.4	0	0.08
	14	10.11	10.11	0	0
	19	10.57	10.54	0	0.03
	20	6.79	6.86	0	-0.07
	21	6.36	6.41	0	-0.05
	22	6.21	6.27	0	-0.06
	23	5.73	5.79	0	-0.06
	24	5.3	5.21	0	0.09
	25	5.23	5.21	0	0.02
	26	5.75	5.62	0	0.13
	27	6.09	6.12	0	-0.03
	28	6.47	6.43	0	0.04
	29	6.67	6.71	0	-0.04
	30	10.77	10.8	0	-0.03

5	3	10.44	10.47	0	-0.03
	4	7.02	6.94	0	0.08
	5	7.4	7.48	0	-0.08
	6	7.34	7.27	0	0.07
	7	6.39	6.42	0	-0.03
	8	8.35	8.41	0	-0.06
	9	8.61	8.78	0	-0.17
	10	6.8	6.91	0	-0.11
	11	7.47	7.46	0	0.01
	12	7.29	7.4	0	-0.11
	13	6.93	6.83	0	0.1
	14	11.01	10.94	0	0.07
	19	11.42	11.16	0	0.26
	20	7.69	7.93	0	-0.24
	21	7.39	7.42	0	-0.03
	22	6.76	6.69	0	0.07
	23	5.77	5.82	0	-0.05
	24	5.5	5.47	0	0.03
	25	5.39	5.4	0	-0.01
	26	5.98	6.04	0	-0.06
	27	6.99	6.7	0	0.29
	28	7.35	7.24	0	0.11
	29	7.44	7.57	0	-0.13
	30	10.62	10.57	0	0.05
6	3	8.14	8.13	0	0.01
	4	5.68	5.71	0	-0.03
	5	6.16	6.19	0	-0.03
	6	7.02	6.96	0	0.06
	7	5.64	5.69	0	-0.05
	8	7.91	7.88	0	0.03
	9	8.09	8.14	0.15	-0.05
	10	5.93	5.85	0.3	0.08
	11	7.22	7.01	0.3	0.21
	12	6.01	5.85	0.15	0.16
	13	7.67	7.87	0	-0.2
	14	7.57	7.58	0	-0.01
	19	10.42	10.47	0	-0.05
	20	6.32	6.33	0	-0.01
	21	6.38	6.34	0	0.04
	22	6.4	6.33	0	0.07
	23	5.52	5.39	0	0.13
	24	5.05	5.1	0	-0.05
	25	5.03	4.76	0	0.27
	26	5.51	5.41	0.1	0.1
	27	6.24	5.87	0.2	0.37
	28	6.2	5.95	0.1	0.25
	29	6.35	6.38	0	-0.03
	30	10.3	10.19	0	0.11

CURRICULUM VITAE

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Education

Univeristy of Louisville School of Dentistry, Louisville, KY
- Orthodontic Residency, July 2009 - June 2011

University of North Carolina School of Dentistry, Chapel Hill, NC
- D.D.S. with Honors, May 2008

Brigham Young University, Provo, UT
- B.S. Neuroscience Cum Laude, August 2004

Work Experience

ATA College, Louisville, KY (10/09-present)
- Adjunct Instructor - teach courses in dental assisting program

North Bullitt Family Dental, Shepherdsville, KY (7/09-present)
- Work Saturday mornings as a general dentist

First Choice Community Health Care, Edgewood, NM (6/08-6/09)
- Lead general dentist at a non-profit community health clinic in underserved area

Awards/Honors

Student Research Achievement Award (2008)
Student Research Fellowship (2007)
AADR Student Research Fellowship (2007)
Bawden Research Award (2/07)
Comprehensive Center for Inflammatory Disorders Fellowship (6/06-6/07)
Brauer Research Fellowship (6/05-6/06)
Dean's List (Fall 2004 – present)
Ira A. and Mary Lou Fulton Scholarship (2003-2004)
University Scholarship (1997-1998; 2002-2004)
Hewlett Packard Employee Scholarship (1997)
Eagle Scout (1994)

Licenses/Professional Memberships

American Association of Orthodontists (08/09-present)
Kentucky State Dental License – 8781 (6/09-present)
New Mexico State Dental License - DD3001 (6/08-present)
American Dental Association (9/04-present)
American Student Dental Association (9/04-5/08)
Student Research Group (09/05-05/08)
America Dental Education Association (1/06-06/08)
International Association for Dental Research (1/06-05/08)