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ORTHODONTISTS' AND PARENTS' PERSPECTIVE OF OCCLUSION IN VARYING  
ANTERIOR-POSTERIOR POSITIONS: A COMPARATIVE STUDY

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science  
in Dentistry at Virginia Commonwealth University.

By

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## ACKNOWLEDGEMENT

I would like to first thank the Virginia Commonwealth University Department of Orthodontics for the opportunity to develop the clinical and didactic skills necessary to excel in an orthodontic career in a welcoming and supportive environment. Specifically, I would like to express my sincere gratitude to Dr. Bhavna Shroff for her encouragement, assistance, and commitment. She has continually exceeded all required responsibilities to ensure successful completion of this project and guide my professional development. Additionally, I would like to thank Drs. Steven Lindauer, Eser Tüfekçi, and Caroline Carrico for their contributions and thoughtful input. Furthermore, I would like to extend my gratitude to my co-residents for creating a positive and constructive environment to learn and grow. I would also like to thank Jamie Dodd for the countless hours spent meticulously measuring and inputting data. Lastly, I would like to thank my family, most notably my wife, Misha, for her love, patience, and unselfishness to allow me to pursue my career dreams and our daughter, Kaylee, for providing endless joy and inspiration.

## TABLE OF CONTENTS

ACKNOWLEDGEMENT .....	ii
LIST OF TABLES .....	iv
LIST OF FIGURES .....	vi
LIST OF APPENDICES .....	vii
ABSTRACT.....	ii
INTRODUCTION .....	1
MATERIALS AND METHODS.....	4
RESULTS .....	8
DISCUSION .....	24
CONCLUSIONS.....	40
REFERENCES .....	41
APPENDICES .....	49
VITA.....	69

## LIST OF TABLES

<b>Table 1.</b> Survey Order.....	6
<b>Table 2.</b> Intra and Inter-Reliability Scores.....	8
<b>Table 3:</b> Survey Demographics.....	9
<b>Table 4.</b> Factors Associated with Outcome Acceptability.....	10
<b>Table 5.</b> Pairwise Comparisons for VAS by Respondent and Malocclusion.....	12
<b>Table 6.</b> Pairwise Comparison for VAS by Respondent and Compliance.....	13
<b>Table 7.</b> Pairwise Comparisons for VAS by Respondent and Treatment Time.....	14
<b>Table 8.</b> Orthodontists' Acceptability of Treatment for Associated Factors.....	15
<b>Table 9.</b> Average VAS Score for Orthodontists by Gender.....	15
<b>Table 10.</b> Parent Acceptability of Treatment for Associated Factors.....	16
<b>Table 11.</b> Factors Associated with Extension of Treatment Time.....	17
<b>Table 12.</b> All Pairwise Comparisons for Differences in Additional Treatment Time.....	19
<b>Table 13.</b> Pairwise Comparison for Additional Treatment Months based on Respondent and Compliance.....	20
<b>Table 14.</b> Pairwise Comparison of Additional Treatment Months based on Completed Months and Respondent Type.....	22
<b>Table 15.</b> Factors Associated with Orthodontists for Extension of Treatment.....	23
<b>Table 16.</b> Pairwise Comparison of Extension of Treatment Length by Years in Practice for Orthodontists.....	24
<b>Table 17.</b> Factors Associated with Parents for Extension of Treatment.....	24
<b>Table 18.</b> Orthodontist and Parent Response for Ideal and Actual Treatment Times.....	26

<b>Table 19.</b> Comparison of Orthodontists and Parents Perception of Ideal and Actual Reported Treatment Times .....	28
<b>Table 20.</b> Average Treatment Times (Actual, Ideal) by Respondent in Months .....	29
<b>Table 21.</b> Comparison of Average Treatment Times (Actual, Ideal) between Orthodontists and Parents.....	29

## LIST OF FIGURES

<b>Figure 1.</b> Estimated Acceptability by Respondent and Malocclusion .....	11
<b>Figure 2.</b> Adjusted Acceptability by Respondent and Compliance .....	13
<b>Figure 3.</b> Estimated Acceptability by Respondent and Treatment Time .....	14
<b>Figure 4.</b> Orthodontist Average Acceptability by Years in Practice.....	16
<b>Figure 5.</b> Additional Treatment Time in Months by Respondent and Malocclusion .....	18
<b>Figure 6.</b> Additional Treatment Time by Respondent and Compliance .....	20
<b>Figure 7.</b> Additional Treatment Months based on Months Completed and Respondent Type...	21
<b>Figure 8.</b> Additional Treatment Time for Orthodontists by Years in Practice .....	23
<b>Figure 9.</b> Ideal and Actual Treatment Times for Extraction Cases.....	27
<b>Figure 10.</b> Ideal and Actual Treatment Times for Non-Extraction Cases .....	27



LIST OF APPENDICES

**Appendix 1.** Survey to Orthodontists - Version A..... 49

**Appendix 2.** Survey to Parents - Version B..... 59

## ABSTRACT

### ORTHODONTISTS' AND PARENTS' PERSPECTIVE OF OCCLUSION IN VARYING ANTERIOR-POSTERIOR POSITIONS: A COMPARATIVE STUDY

By David H. Lindsey, D.D.S.

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

Virginia Commonwealth University, 2017

Thesis Director: Bhavna Shroff, D.M.D., M.Dent.Sc., M.P.A.

Program Director, Department of Orthodontics

**Objective:** The purpose was to compare orthodontists' and parents' perception of orthodontic treatment outcomes in the anterior-posterior (AP) dimension. Assessment of treatment time and compliance were also investigated.

**Material and Methods:** Parallel surveys for orthodontists (n=1000) and parents (n=750) displayed occlusions from 3 mm Class III (CI III:3) to 3 mm Class II. Participants rated occlusal relationships on a 100 mm VAS from least to most acceptable (0-100).

**Results:** 233 orthodontists (23%) and 243 parents (32%) responded. Orthodontists (mean=93.9, 25.9) and parents (mean=80.7, 40.9) rated Class I (CI I) occlusion most and CI III:3 least acceptable. No significant difference was found between outcomes at 18 months versus 24 months. For all cases, parents were willing to extend treatment duration longer than orthodontists.

**Conclusions:** Orthodontists and parents viewed treatment outcomes in the AP dimension differently, rating CI I as most acceptable. Parents were willing to extend treatment longer than orthodontists.

## INTRODUCTION

The length of orthodontic treatment is important to patients and their parents, and orthodontists must routinely answer questions regarding how much longer treatment will continue. Factors affecting the duration of orthodontic treatment have been investigated and include patient compliance and severity of malocclusion.<sup>1-3</sup> A wide range in the duration of treatment has been reported.<sup>1,2,4,5</sup> The average treatment time among private practice orthodontic offices ranges from 23.1 months to 28.6 months.<sup>1,2</sup> A similar duration of 27.5 months was reported for treatment in a residency program.<sup>4</sup> Wenger et al. found that Class II malocclusions require the greatest amount of time to complete treatment (29.9 months) compared to 26 months for Class I malocclusions and 28 months for Class III malocclusions.<sup>5</sup> Yet, orthodontists and patients desire shorter treatment times, and some advances in dental materials and orthodontic techniques may help shorten treatment duration.<sup>6-9</sup>

In addition to demanding shorter treatment times, multiple studies have demonstrated that orthodontic patients and their parents have high treatment outcome expectations.<sup>10-12</sup> Completing orthodontic treatment may sensitize patients to minor esthetic problems during and after treatment, resulting in even higher esthetic demands.<sup>11</sup> Despite increased awareness by laypeople, orthodontists demonstrate a greater ability to recognize esthetic disharmonies.<sup>10,13,14</sup> The different perception of esthetics by orthodontists and laypeople creates potential discrepancies between how orthodontists and laypeople assess the quality of orthodontic treatment.

Patient cooperation and compliance levels vary noticeably, with poor cooperation and compliance being associated with increased treatment duration.<sup>2</sup> Multiple studies have investigated factors associated with poor compliance, which include patients' sex with males less

cooperative than females, influence of parents, severity of malocclusion, increased missed appointments, and inadequate oral hygiene.<sup>1-3, 15, 16</sup> Fink and Smith proposed that the number of missed appointments correlates with overall compliance.<sup>1</sup> Mehra et al. found that 95% of orthodontists report terminating treatment early in up to 5% of their noncompliant patients. The remaining 5% of orthodontists surveyed routinely end treatment early in 5-10% of their noncompliant patients.<sup>16</sup>

Orthodontists must balance the decision to continue treatment with the potential risks of development of white spot lesions, apical root resorption, periodontal defects, and continued lack of compliance.<sup>17-22</sup> The decision to either continue or prematurely end treatment is further complicated in cases where the patient's chief complaint has been addressed, functional occlusion established, and parents/patients want to cease treatment before the attainment of an ideal occlusion. While adolescent patients' concerns and needs must be considered during treatment, ultimately treatment decisions are determined by the legal guardian, which most commonly is the parent. By determining discrepancies between the orthodontists' and parents' perception of treatment outcomes, the orthodontist can better address patients' expectations.<sup>4, 23</sup> Additionally, understanding parents' perception of malocclusions allows orthodontists to create goals for orthodontic treatment and to recommend treatment that encompasses more than an initial chief complaint.

Previous studies comparing orthodontists and laypeople have relied on facial drawings<sup>24,</sup> <sup>25</sup>, altering intraoral photographs<sup>11, 13, 26</sup>, or modifying full facial photographs.<sup>27-29</sup> In this study digital models were used to analyze perceived preferences of orthodontists compared to laypeople for occlusal changes in the anterior-posterior (AP) dimension. While previous methods were appropriate to evaluate facial and dental esthetics, possible uncontrolled biases were introduced

when using extraoral and intraoral photographs such as tooth shade, lip thickness, and gingival pigmentation.<sup>30,31</sup> Recent studies have verified the efficacy of utilizing digital models as accurate representations of overjet and canine and molar classification.<sup>32, 33</sup> Through digital modeling software, the potential biases of tooth and gingival shades can be controlled. Additionally, the software can allow quantifiable alterations in the AP direction.

With patients' and parents' concerns regarding treatment length and demands for improved smile esthetics, research is needed to determine if patients and parents are willing to compromise the overall treatment outcome for shorter treatment duration. If patients or parents are willing to compromise, the orthodontist also must decide if he/she is willing to compromise the standards of care to meet patients' and parents' expectations.

The specific aims of this study were to compare and quantify orthodontists' and parents': 1) acceptability of occlusal relationships in varying AP positions; 2) perception of orthodontic treatment duration; 3) willingness to extend treatment time to achieve a more acceptable treatment outcome. The null hypothesis was that no statistical differences exist between orthodontists' and parents' preference of occlusal relationships, treatment duration, and willingness to extend treatment time.

## MATERIALS AND METHODS

### **Image Design**

After approval from the Virginia Commonwealth University (VCU) Institutional Review Board (HM20006420), two parallel surveys (for orthodontists and for parents) were developed using images from monochromatic digital models. After obtaining written consent, a patient treated at the VCU Orthodontic Clinic was scanned with the iTero ® HD2.9 intraoral scanner (Align Technology, San Jose, CA) to generate the digital images. The inclusion criteria for the intraoral scan were a fully erupted permanent dentition with the exception of third molars, no tooth-size discrepancy, maxillary and mandibular incisor angulation within normal limits, ideal alignment of teeth, and ideal Class I molar/canine relationship.

The digital models were altered moving the mandibular arch sagittally in 1.0 mm increments up to 3.0 mm anteriorly and 3.0 mm posteriorly using OrthoCAD ® 5.1 software (Align Technology, San Jose, CA), resulting in seven occlusal variations measured at molars and canines: Class III by 3 mm (Cl III:3), Class III by 2 mm (Cl III:2), Class III by 1 mm (Cl III:1), Ideal Class I (Cl I), Class II by 1 mm (Cl II:1), Class II by 2 mm (Cl II:2), Class II by 3 mm (Cl II:3). Overjet ranged from -1.0 mm to 5.0 mm. For each variation, right buccal, center, and left buccal images were displayed. To maintain consistency between the occlusion on the left and right buccal views, the left image was a mirror image of the right buccal occlusion. The vertical and transverse dimension were held constant for the digital alterations with the exception of the Cl III:2 image, which was digitally altered vertically using Adobe Photoshop ® (Adobe Systems Incorporated, San Jose, CA) to represent an edge to edge anterior occlusion.

## **Participants**

The orthodontist surveys (Appendix A1) were mailed to 1,000 orthodontists randomly selected from a geographical weighted representation of all 9,277 active U.S. members of the American Association of Orthodontists (AAO). The weighted representation was developed to limit location bias of respondents by determining the ratio of active AAO members per state to total U.S. active AAO members. The parent surveys (Appendix A2) were given to 750 parents of children currently in active orthodontic treatment who did not receive Phase I orthodontic therapy or previous comprehensive treatment. Parent participants were randomly selected from 15 different orthodontic offices, including the VCU Orthodontic Clinic. The remaining 14 orthodontic offices were selected from the current members of Virginia Orthodontic Education and Research Foundation and practicing part-time faculty members of VCU Department of Orthodontics. The orthodontic practices were located in Virginia, North Carolina, and Idaho. Each of the 15 offices received 50 questionnaire packets.

## **Measurements**

Using a 100 mm visual analogue scale (VAS) anchored by “least acceptable” and “most acceptable”, participants were asked to mark their preference for each of the seven varying occlusal relationships. For the control, a repeat of the ideal occlusal relationship was included to measure participant reliability. Thus, a total of eight cases were presented to participants. The order of the eight sets was randomized utilizing a random number generator within Microsoft Excel ® (Microsoft Corporation, Redmond, WA). All VAS scores were measured using Fowler 6”/150 mm Electronic Caliper 54-100-77-2 (Fred V Fowler Co Inc., Newton, MA) by two examiners (DL and JD). Inter-rater and intra-rater reliability were determined by each examiner independently

measuring 50 VAS scores, then repeating the measurements 7 days later.

### **Treatment Duration**

To investigate if the amount of time in treatment impacted the orthodontists' and parents' perception of treatment outcome or willingness to extend orthodontic treatment to achieve a more desired occlusal relationship, each case was presented at 18 months or 24 months of orthodontic treatment. For both the orthodontist and parent surveys, two versions (A and B) were created. Each version displayed the eight sets of images at either 18 months or 24 months. A random number generator within Microsoft Excel® (Microsoft Corporation, Redmond, WA) determined which version of the survey contained the 18 month or 24 month image set (Table 1).

**Table 1.** Survey Order.

<b>Version A</b>	<b>Version B</b>
1) CI I – 24 months	1) CI II:3 – 18 months
2) CI II:2 – 18 months	2) CI III:2 – 24 months
3) CI III:3 – 18 months	3) CI I – 18 months
4) CI III:2 – 18 months	4) CI III:3 – 24 months
5) CI II:1 – 18 months	5) CI II:2 – 24 months
6) CI I – 24 months	6) CI II:1 – 24 months
7) CI II:3 – 24 months	7) CI III:1 – 18 months
8) CI III:1 – 24 months	8) CI I – 18 months



## **Data Collection**

The orthodontist surveys were sent by mail. Initial nonresponders received a second mailing 6 weeks after the initial mailing. The parent surveys were delivered to each participating office with no second round of mailing. Study data were collected and managed using REDCap (Research Electronic Data Capture) software hosted at VCU. This program is a secure web-based application designed to support data capture for research studies, data verification and export procedures to statistical packages.<sup>34</sup>

## **Statistical Analysis**

Outcome acceptability (VAS score 0 – 100 mm) and additional treatment time were estimated using repeated measures analysis to account for variability among respondents. Parameters included in all models were the respondent type (orthodontists or parents), case malocclusion, treatment duration (18 or 24 months), and compliance. Additionally, two-way interactions were fit to determine potential differences in the effect of malocclusion, treatment time, and patient compliance between parents and orthodontists. All post hoc pairwise comparisons were adjusted using Tukey's HSD to account for multiple comparisons. A significance level of 0.05 was set for all statistical models. SAS Enterprise Guide v.6.1 (SAS Institute Inc., Cary, NC) was used for all analyses.

## RESULTS

### Rater Calibration

The two examiners (DL and JD) were nearly identical in measuring the calibration data with an inter-rater reliability of 0.99 (Table 2). The strong correlation for both the intra-rater and inter-rater reliability measurements of the initial 50 VAS scores provided confidence for the accuracy of the complete data set.

**Table 2.** Intra and Inter-Reliability Scores

	Correlation
Rater 1	0.99781
Rater 2	0.99999
Inter-Rater	0.99881

### Control Measurements

The average difference between the two scores for the control image was 0.46 (SD=16.95). The two scores were compared using TOST for equivalence and found to be equivalent within  $\pm 2$  on the VAS (90% CL on mean: -0.84 – 1.76).

### Survey Demographics

The data were collected from July through November 2016. The response rates were 23% (n = 233) and 32% (n = 243) for orthodontists and parents, respectively (Table 3). For orthodontists, 78% of respondents were male and 22% were female. Orthodontists with American Board of Orthodontics (ABO) certification represented 38% of the total respondents. The majority

of orthodontists that responded (79%) had been in practice 30 years or less. For parents, 14% of respondents were male and 86% were females. The majority of parents (82%) were between 35 to 54 years old with 94% of the children in treatment were between 11 to 16 years old.

**Table 3: Survey Demographics**

<b>Parents</b>				<b>Orthodontists</b>			
		<b>n</b>	<b>%</b>			<b>n</b>	<b>%</b>
Response Rate		243	32%	Response Rate		233	23%
Gender				Gender			
	Male	33	14%		Male	181	78%
	Female	203	86%		Female	50	22%
Age (years)				ABO Certified		87	38%
	25-34	24	10%	Years in Practice			
	35-44	110	46%		1-10	57	25%
	45-54	86	36%		11-20	69	30%
	55-64	15	6%		21-30	56	24%
	65+	3	1%		31-40	37	16%
Child: Gender					41 +	13	6%
	Male	107	45%				
	Female	130	55%				
Child: Age (years)							
	8-10	8	3%				
	11-13	130	55%				
	14-16	92	39%				
	17+	7	3%				
Child: Months of Treatment Completed							
	1-6	52	22%				
	7-12	42	18%				
	13-18	100	43%				
	19-24	23	10%				

**Outcome Acceptability: Associated Factors**

Factors associated with overall acceptability of treatment outcomes included malocclusion, compliance of the patient, type of respondent (orthodontist or parent), and time in treatment (Table 4). The interaction between respondent type and malocclusion had the strongest association (p-

value<0.0001). A significant interaction (p-value<0.0001) was also found between respondent type and patient compliance. Post hoc pairwise comparisons are given below.

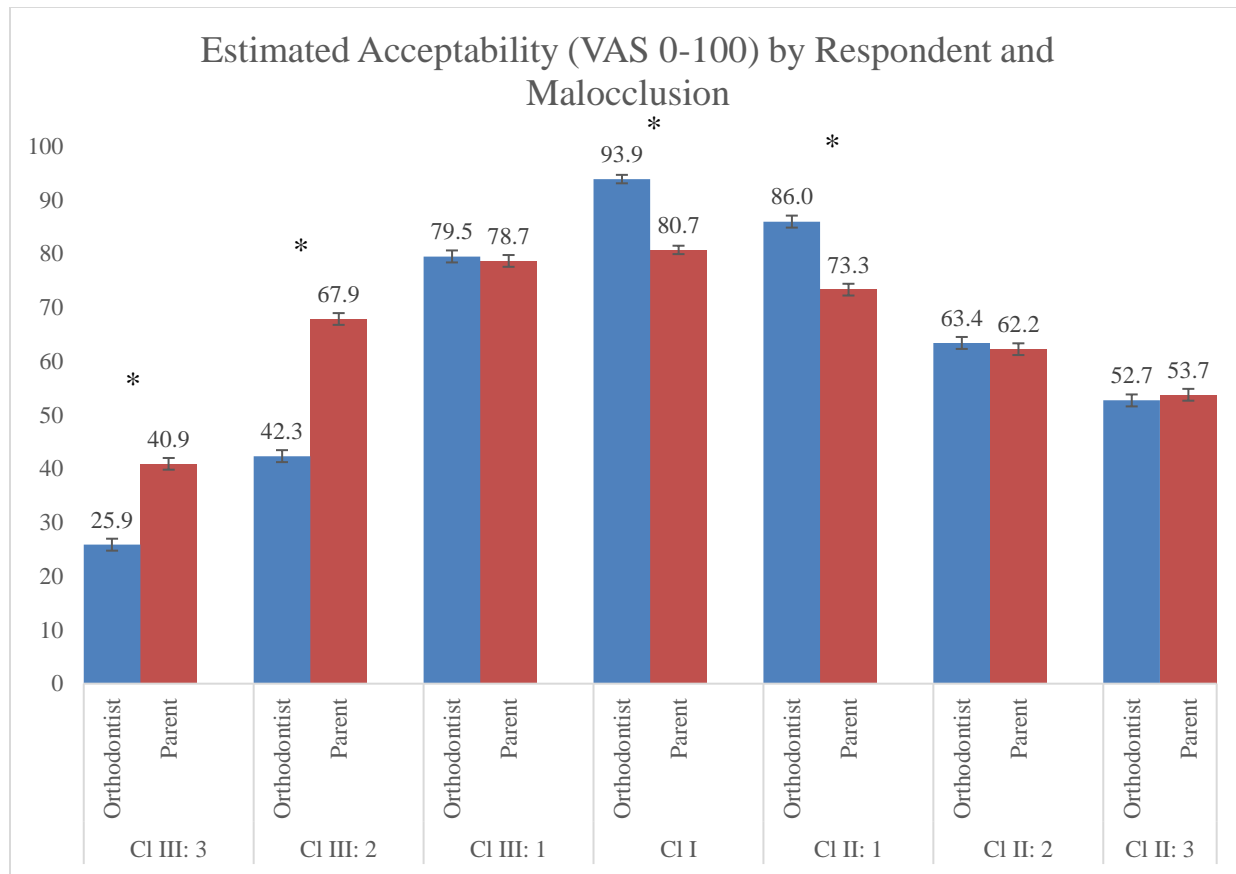
**Table 4.** Factors Associated with Outcome Acceptability

<b>Effect</b>	<b>F Value</b>	<b>P-value</b>	
Respondent	11.97	0.0006	*
Time	2.55	0.1112	
Compliant	117.98	<.0001	*
Malocclusion	711.59	<.0001	*
Respondent*Malocclusion	94.73	<.0001	*
Respondent*Compliant	36.75	<.0001	*
Respondent*Time	3.5	0.0619	

\*Tukey's adjusted P-value =.05

### **Outcome Acceptability: Malocclusion by Respondent Type**

Both orthodontists and parents rated Class I as the most acceptable treatment outcome with estimated mean scores of 93.9 and 80.7, respectively (Figure 1). Orthodontists and parents also agreed in scoring CI III:3 as the least acceptable treatment outcome with estimated mean scores of 25.9 and 40.9, respectively. Significant differences between orthodontists' and parents' perceptions of treatment outcomes were found for four of the malocclusions (CI III:3, CI III:2, CI I, and CI II:1). For the remaining three malocclusions (CI III:1, CI II:2, and CI II:3), orthodontists and parents scored treatment outcomes similarly.



**Figure 1.** Estimated Acceptability by Respondent and Malocclusion

\* Indicates significant difference between orthodontists and parents at 0.05 level (Tukey's adjusted)

The largest difference in perception of acceptability between orthodontists and parents was  $25.5 \pm 1.56$  for CI III:2 with parents rating occlusion significantly more acceptable than orthodontists (Table 5). Orthodontists rated each occlusal variation statistically different, while parents did not show a statistical difference in the acceptability between CI I and CI III:1 ( $2.0 \pm 1.35$ ). For orthodontists, the greatest change in the level of acceptability between two consecutive cases was between CI III:1 and CI III:2 ( $37.2 \pm 1.58$ ). For parents, the greatest change between two consecutive cases was between CI III:2 and CI III:3 ( $27.0 \pm 1.54$ ).

**Table 5.** Pairwise Comparisons for VAS by Respondent and Malocclusion

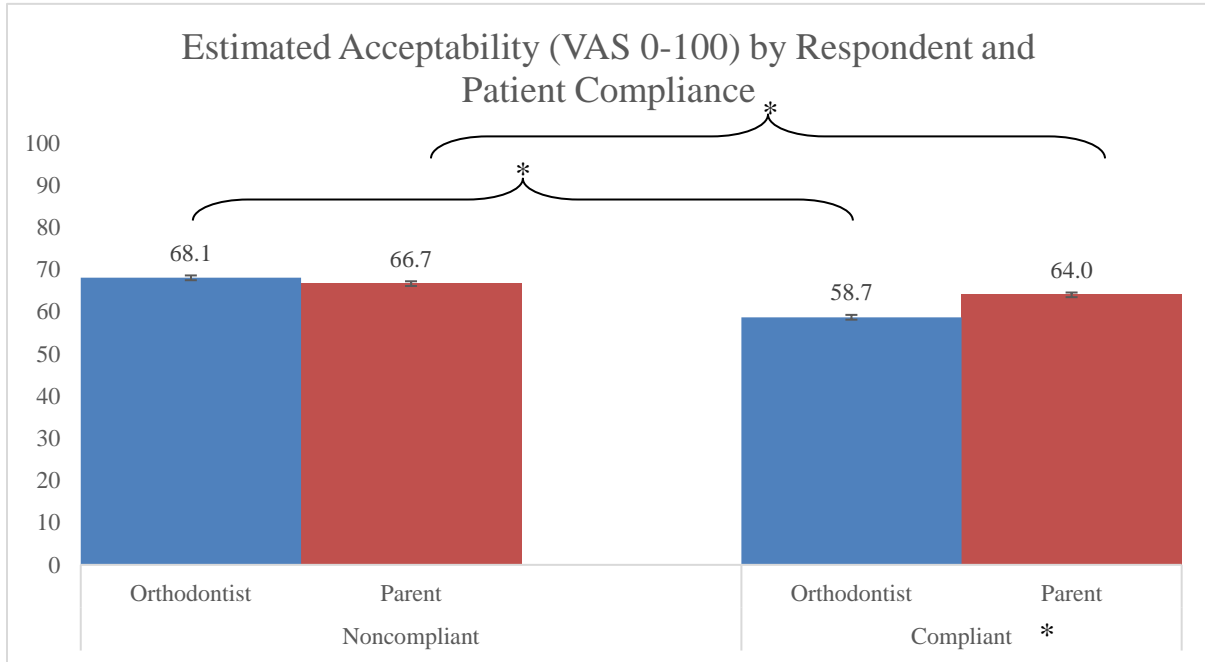
<b>Comparison</b>	<b>Estimated Difference</b>	<b>SE</b>	<b>P-value</b>	
Cl II:1 Orthodontists vs Parents	12.7	1.56	<.0001	*
Cl III:1 Orthodontists vs Parents	0.8	1.57	1	
Cl II:2 Orthodontists vs Parents	1.2	1.56	1	
Cl III:2 Orthodontists vs Parents	-25.5	1.56	<.0001	*
Cl II:3 Orthodontists vs Parents	-1.0	1.57	1	
Cl III:3 Orthodontists vs Parents	-15.0	1.56	<.0001	*
Cl I: Orthodontists vs Parents	13.2	1.11	<.0001	*
Orthodontists: Class II:1 vs Cl III:1	6.5	1.58	0.0033	*
Orthodontists: Cl II:1 vs Cl II:2	22.6	1.58	<.0001	*
Orthodontists: Cl II:1 vs Cl I	-7.9	1.37	<.0001	*
Orthodontists: Cl III:1 vs Cl III:2	37.2	1.58	<.0001	*
Orthodontists: Cl III:1 vs Cl I	-14.4	1.37	<.0001	*
Orthodontists: Cl II:2 vs Cl III:2	21.1	1.57	<.0001	*
Orthodontists: Cl II:2 vs Cl II:3	10.7	1.57	<.0001	*
Orthodontists: Cl II:3 vs Cl III:3	26.8	1.57	<.0001	*
Parents: Cl II:1 vs Cl III:1	-5.3	1.55	0.0375	*
Parents: Cl II:1 vs Cl II:2	11.1	1.55	<.0001	*
Parents: Cl II:1 vs Cl I	-7.4	1.34	<.0001	*
Parents: Cl III:1 vs Cl III:2	10.8	1.55	<.0001	*
Parents: Cl III:1 vs Cl I	-2.0	1.35	0.9644	
Parents: Cl II:2 vs Cl III:3	8.5	1.55	<.0001	*
Parents: Cl III:2 vs Cl III:3	27.0	1.54	<.0001	*
Parents: Cl II:3 vs Cl III:3	12.8	1.55	<.0001	*

\*Indicates statistically significant difference (Tukey's adjusted P-value)

### **Outcome Acceptability: Compliance by Respondent Type**

Both orthodontists and parents rated treatment outcomes for noncompliant patients significantly more acceptable than treatment outcomes for compliant patients (Figure 2). Pairwise comparison of respondent and compliance regardless of malocclusion or treatment duration showed differences in the estimated VAS means (Table 6). Orthodontists and parents did not significantly differ in VAS scores for the noncompliant patients ( $p=0.3048$ ). For the compliant patients, parents rated the treatment outcomes significantly higher than orthodontists (VAS mean score of 64.0 versus 58.7, respectively) for a significant estimated difference of  $5.3 \pm 0.79$  ( $p-$

value<0.0001).



**Figure 2.** Adjusted Acceptability by Respondent and Compliance

\* Indicates significant at 0.05 level (Tukey's adjusted)

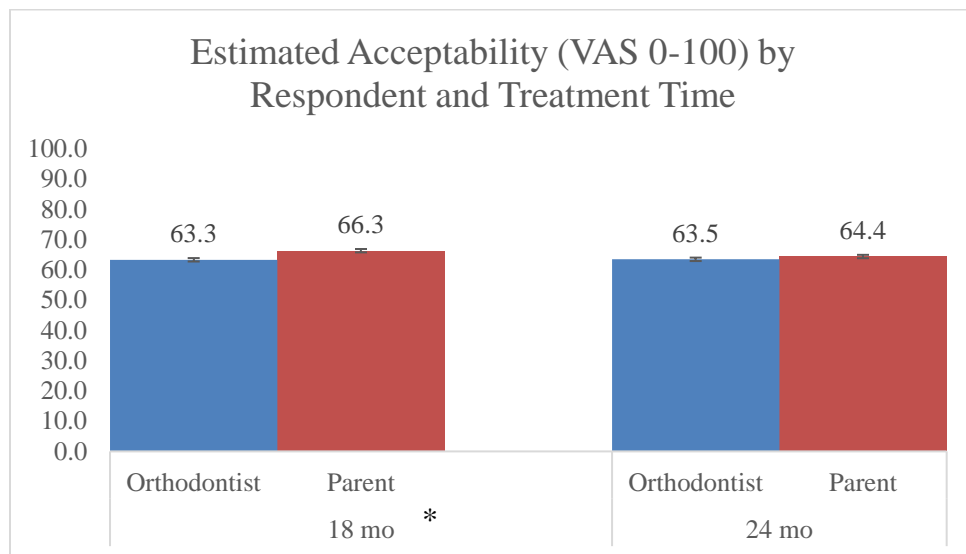
**Table 6.** Pairwise Comparison for VAS by Respondent and Compliance

Comparison	Estimated Difference	SE	P-value
Noncompliant: Orthodontists vs Parents	1.4	0.80	0.3048
Compliant: Orthodontists vs Parents	-5.3	0.79	<.0001*
Orthodontists: Noncompliant vs Complaint	9.4	0.79	<.0001*
Parents: Noncompliant vs Compliant	2.7	0.78	0.0038*

\* Indicates significant at 0.05 level (Tukey's adjusted)

### Outcome Acceptability: Treatment Time by Respondent Type

While controlling for compliance and type of malocclusion, a significant difference was found between orthodontists' and parents' ratings of treatment outcomes at 18 months (p-value=0.0010) (Figure 3). No statistical difference was found between orthodontists' and parents' ratings of treatment outcomes at 24 months (p-value=0.64). No statistical differences were found for orthodontists' nor parents' preference for treatment outcomes at 18 months compared to 24 months (Table 7).



**Figure 3.** Estimated Acceptability by Respondent and Treatment Time  
\* Indicates significant at 0.05 level (Tukey's adjusted)

**Table 7.** Pairwise Comparisons for VAS by Respondent and Treatment Time

Comparison	Estimated Difference	SE	P-value
18 months: Orthodontists vs Parents	-3.0	0.80	0.0010*
24mo: Orthodontists vs Parents	-0.9	0.79	0.6403
Orthodontists: 18mo vs 24mo	-0.2	0.79	0.9974
Parents: 18mo vs 24mo	1.9	0.78	0.0661

\* Indicates significant at 0.05 level (Tukey's adjusted)



## Outcome Acceptability: Respondent Type

### *Orthodontists*

After adjusting for time in treatment, compliance, and malocclusion, significant differences in case acceptability were found for gender and years in practice when orthodontists' responses were analyzed separately (Table 8). ABO certified orthodontists and non-ABO certified orthodontists did not differ significantly in scoring treatment outcomes (p-value=0.18). Females scored treatment outcomes lower than males with an average difference of 4.5 between genders (Table 9). Initially, the number of years in practice indicated a significant difference in the acceptance of malocclusions (p-value=0.04); however after adjusting for multiple comparisons, no statistical differences were seen among each interval of years in practice (Figure 4). Orthodontists in practice for 11 to 30 years, on average, scored treatment outcomes marginally higher than both orthodontists practicing less than 11 years or more than 30 years.

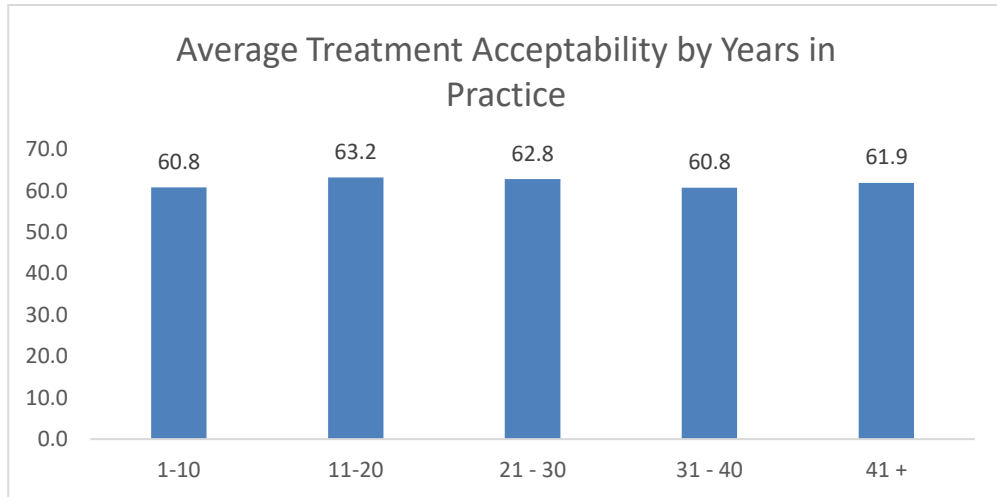
**Table 8.** Orthodontists' Acceptability of Treatment for Associated Factors

<b>Effect</b>	<b>P-value</b>
Time in Treatment	0.5389
Compliance	<.0001*
Malocclusion	<.0001*
ABO Certified (Yes vs No)	0.1842
Years in Practice	0.0414*
Gender	<.0001*

\* Indicates significant at 0.05 level (Tukey's adjusted)

**Table 9.** Average VAS Score for Orthodontists by Gender

<b>Gender</b>	<b>Average VAS</b>	<b>Standard Error</b>
Female	59.7	0.8132
Male	64.2	0.4483



**Figure 4.** Orthodontist Average Acceptability by Years in Practice

*Parents*

Significant differences were found for VAS scores of malocclusion acceptability when analyzing parent responses individually (Table 10). After adjusting for case treatment time (18 months vs 24 months), compliance, and malocclusion, parents’ gender and current treatment duration for their child were not significant.

**Table 10.** Parent Acceptability of Treatment for Associated Factors

<b>Effect</b>	<b>P-value</b>
Time in Treatment	0.0646
Compliance	0.0073 *
Malocclusion	<.0001 *
Gender: Guardian	0.118
Age of Child	0.0594
Gender: Child	0.0731
Child: Months Treatment Completed	0.1087

\* Indicates significant at 0.05 level (Tukey’s adjusted)

### Extension of Treatment Length: Associated Factors

Significant differences were found in the amount of time orthodontists and parents were willing to extend treatment duration (Table 11). As with outcome acceptability, many factors were dependent on respondent type. Malocclusion and patient compliance were associated with respondent type (p-value<0.0001). Time in treatment was not associated with respondent type (p-value=0.2853).

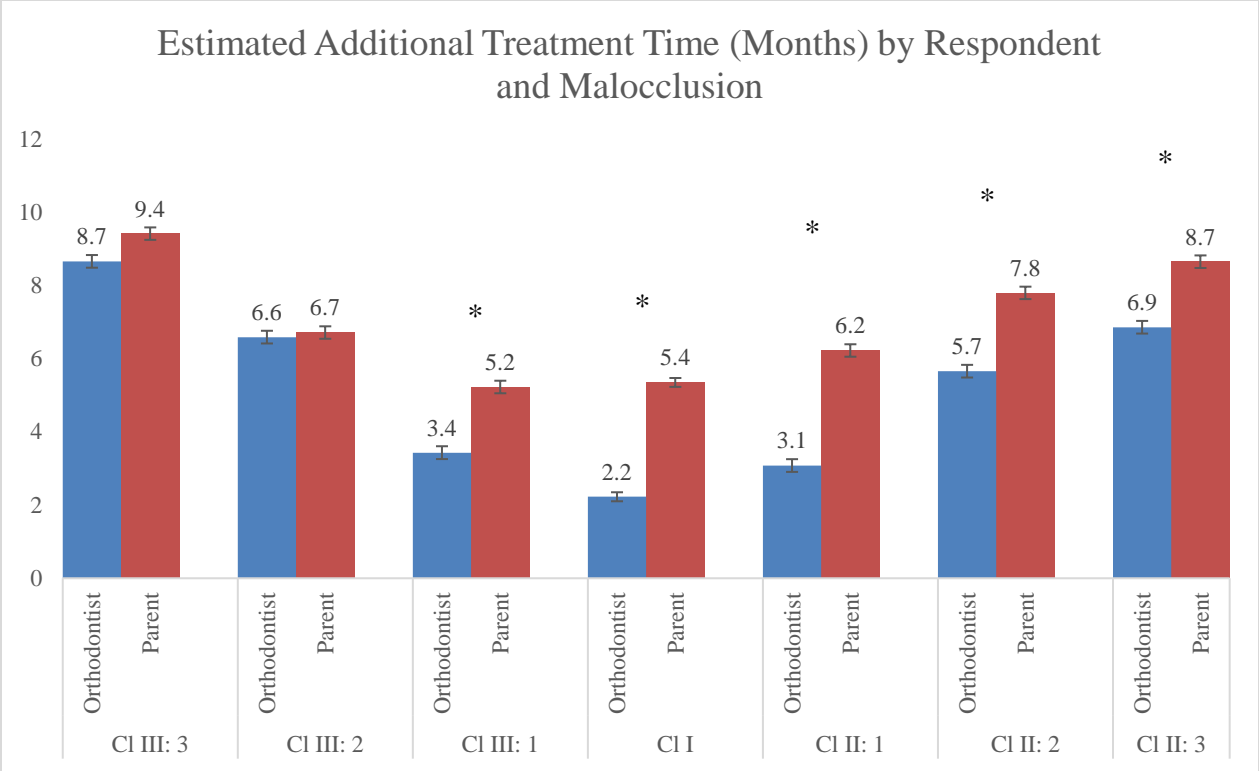
**Table 11.** Factors Associated with Extension of Treatment Time

Effect	F Value	P-value
Respondent	430.4	<.0001 *
Time	23.92	<.0001 *
Compliant	99.65	<.0001 *
Malocclusion	308.31	<.0001 *
Respondent*Malocclusion	25.32	<.0001 *
Respondent*Compliant	68.86	<.0001 *
Respondent*Time	1.14	0.2853

\* Indicates significant at 0.05 level (Tukey's adjusted)

### Extension of Treatment Length: Malocclusion by Respondent Type

For each type of malocclusion, parents were willing to extend treatment longer than orthodontists (Figure 5). Although parents would continue treatment longer in CI III:3 and CI III:2, the differences of  $-0.8 \pm 0.24$  months (p-value = 0.099) and  $-0.1 \pm 0.24$  months (p-value = 1), respectively, between orthodontists and parents were not significantly different (Table 12). The largest discrepancies between orthodontists and parents' extension of treatment were for CI I ( $3.1 \pm 0.17$  months) and CI II:1 ( $3.1 \pm 0.24$  months).



**Figure 5.** Additional Treatment Time in Months by Respondent and Malocclusion  
 \* Indicates significant at 0.05 level (Tukey's adjusted)

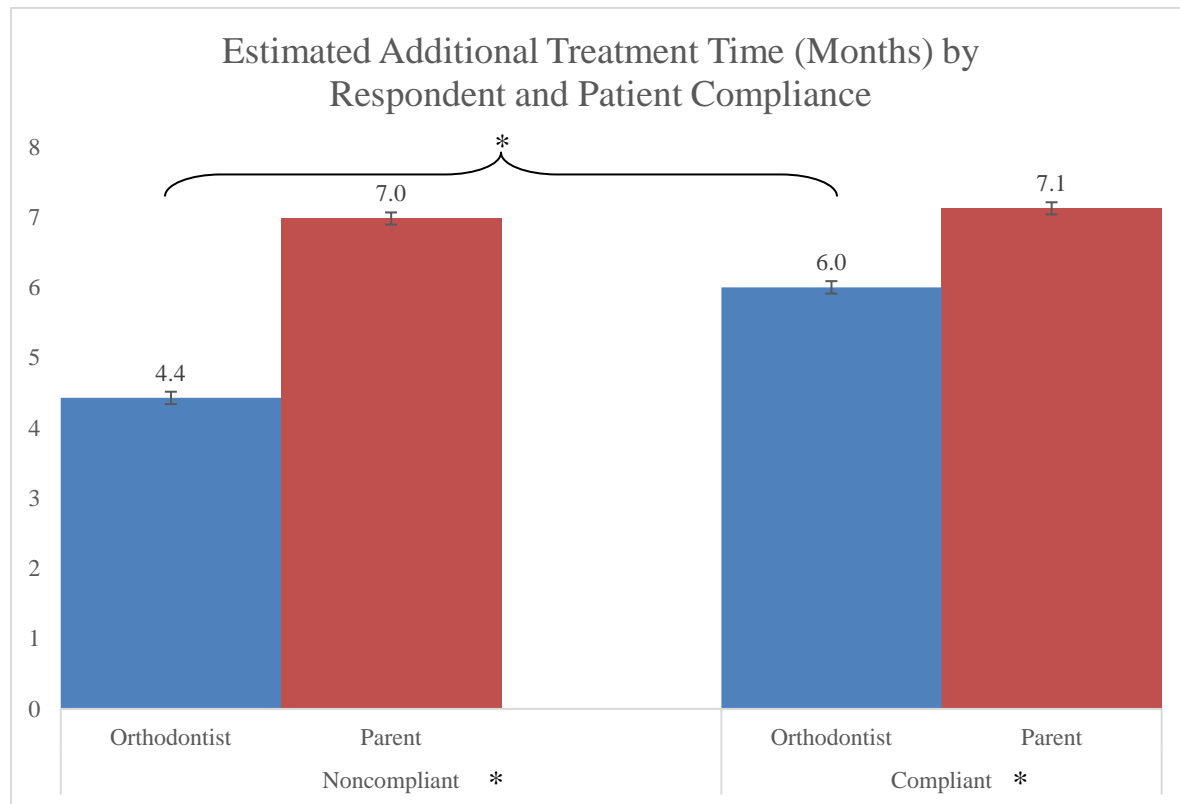
**Table 12.** All Pairwise Comparisons for Differences in Additional Treatment Time

<b>Comparison</b>	<b>Difference in Additional Treatment Months</b>	<b>SE</b>	<b>P-value</b>	
Cl II:1 Orthodontists vs Parents	-3.1	0.24	<.0001	*
Cl III:1 Orthodontists vs Parents	-1.8	0.25	<.0001	*
Cl II:2 Orthodontists vs Parents	-2.1	0.24	<.0001	*
Cl III:2 Orthodontists vs Parents	-0.1	0.24	1	
Cl II:3 Orthodontists vs Parents	-1.8	0.24	<.0001	*
Cl III:3 Orthodontists vs Parents	-0.8	0.24	0.0999	
Cl I: Orthodontists vs Parents	-3.1	0.17	<.0001	*
Orthodontists: Cl II:1 vs Cl III:1	-0.4	0.25	0.9787	
Orthodontists: Cl II:1 vs Cl II:2	-2.6	0.25	<.0001	*
Orthodontists: Cl II:1 vs Cl I	0.9	0.21	0.0048	*
Orthodontists: Cl III:1 vs Cl I	1.2	0.21	<.0001	*
Orthodontists: Cl II:2 vs Cl III:2	-0.9	0.24	0.0108	*
Orthodontists: Cl II:2 vs Cl III:3	-1.2	0.24	<.0001	*
Orthodontists: Cl III:2 vs Cl III:3	-2.1	0.25	<.0001	*
Orthodontists: Cl II:3 vs Cl III:3	-1.8	0.25	<.0001	*
Parents: Cl II:1 vs Cl III:1	1.0	0.24	0.003	*
Parents: Cl II:1 vs Cl II:2	-1.6	0.24	<.0001	*
Parents: Cl II:1 vs Cl I	0.9	0.21	0.0025	*
Parents: Cl III:1 vs Cl III:2	-1.5	0.24	<.0001	*
Parents: Cl III:1 vs Cl I	-0.1	0.21	1	
Parents: Cl II:2 vs Cl III:2	1.1	0.24	0.0006	*
Parents: Cl II:2 vs Cl II:3	-0.9	0.24	0.0283	*
Parents: Cl III:2 vs Cl III:3	-2.7	0.24	<.0001	*

\* Indicates significant at 0.05 level (Tukey's adjusted)

### **Extension of Treatment Length: Patient Compliance by Respondent Type**

With respect to compliance, orthodontists and parents significantly differed in the amount of time each would continue orthodontic treatment (Figure 6). For compliant patients, orthodontists would end treatment  $1.1 \pm 0.12$  months earlier than parents (Table 13). For noncompliant patients, orthodontists would end treatments  $2.6 \pm 0.12$  months earlier than parents. Orthodontists would extend treatment  $1.6 \pm 0.12$  months longer for compliant patients compared to treatment for noncompliant patients. On average, parents would continue treatment an additional 7 months regardless of level of compliance.



**Figure 6.** Additional Treatment Time by Respondent and Compliance

\* Indicates significant at 0.05 level (Tukey's adjusted)

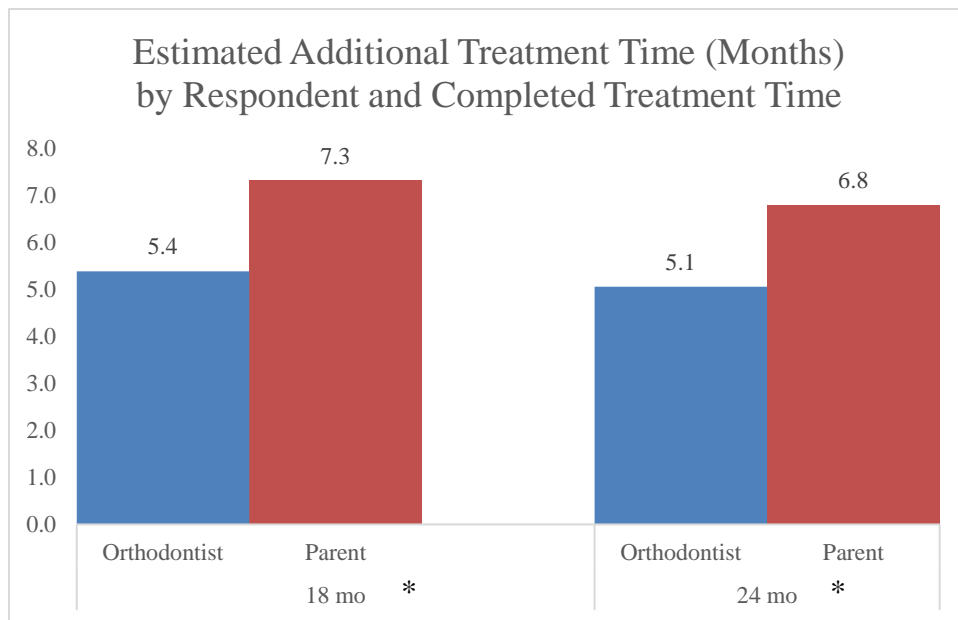
**Table 13.** Pairwise Comparison for Additional Treatment Months based on Respondent and Compliance

Comparison	Difference in Additional Treatment Months	SE	P-value
Compliant: Orthodontists vs Parents	-1.1	0.12	<.0001*
Noncompliant: Orthodontists vs Parents	-2.6	0.12	<.0001*
Orthodontists: Noncompliant vs Compliant	-1.6	0.12	<.0001*
Parents: Noncompliant vs Compliant	-0.1	0.12	0.6265

\* Indicates significant at 0.05 level (Tukey's adjusted)

### Extension of Treatment Length: Completed Treatment Time

Significant differences were found between orthodontists' and parents' willingness to extend treatment duration for outcomes at 18 months compared to outcomes at 24 months (Figure 7). Parents would extend treatment  $1.9 \pm 0.1$  months and  $1.7 \pm 0.1$  months longer than orthodontists for treatment outcomes at 18 months and 24 months, respectively (Table 14). Parents extended treatment  $0.5 \pm 0.1$  months longer if occlusion presented was at 18 months instead of 24 months ( $p$ -value  $< 0.0002$ ). Orthodontists extended treatment  $0.3 \pm 0.1$  months for 18 month cases compared to 24 month cases ( $p$ -value  $< 0.0381$ ).



**Figure 7.** Additional Treatment Months Based on Months Completed and Respondent Type  
\* Indicates significant at 0.05 level (Tukey's adjusted)

**Table 14.** Pairwise Comparison of Additional Treatment Months based on Completed Months and Respondent Type

<b>Comparison</b>	<b>Estimated Difference in Additional Treatment Time</b>		
	<b>SE</b>	<b>P-value</b>	
Orthodontists: 18 vs 24 Months	0.3	0.1	0.0381*
18 Months: Orthodontists vs Parents	-1.9	0.1	<.0001*
24 Months: Orthodontists vs Parents	-1.7	0.1	<.0001*
Parents: 18 Months vs 24 Months	0.5	0.1	0.0002*

\* Indicates significant at 0.05 level (Tukey’s adjusted)

### **Extension of Treatment Length: Respondent Type**

#### *Orthodontists*

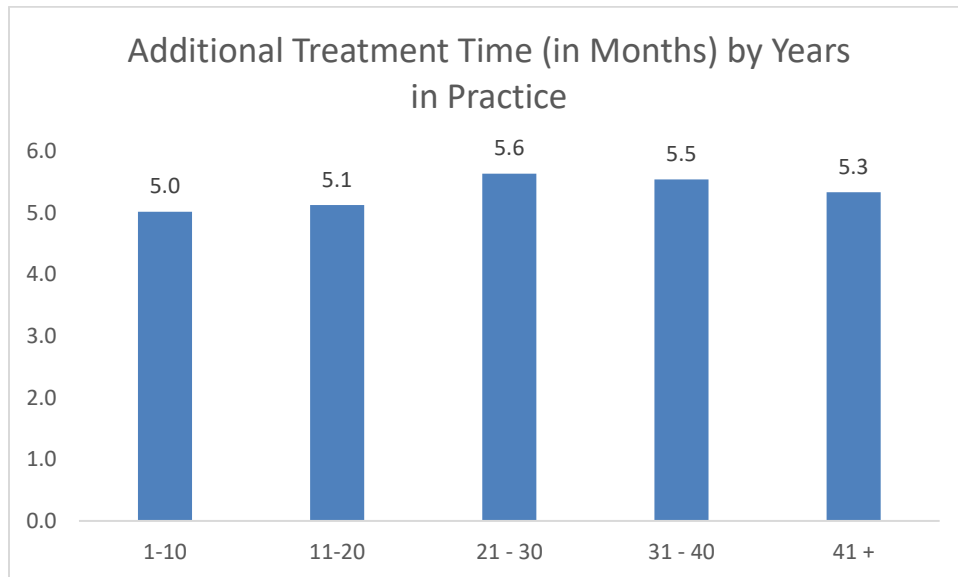
After adjusting for time in treatment, compliance, and malocclusion strictly for orthodontists, a number of factors including ABO certification, years in practice, and gender of practitioner were associated with differences in estimated extensions of treatment time (Table 15). Non-ABO certified orthodontists would extend treatment an estimated difference of 0.3 months longer than ABO certified orthodontists. The impact of the number of years in practice differed significantly. Orthodontists within the first 1 to 10 years of practice extended treatment the least at 5 months, on average, and orthodontists within 21 to 30 years of practice extended treatment the most at 5.6 months, on average (Figure 8). A significant difference was found between the orthodontists practicing 21 to 30 years and those within the first 20 years of practice (Table 16). Orthodontists within the first 10 years of practice also would extend treatment duration significantly less than practitioners with 31 to 40 years of experience (p-value=0.0169).



**Table 15.** Factors Associated with Orthodontists for Extension of Treatment

<b>Effect</b>	<b>P-value</b>
Time in Treatment	0.0013*
Compliance	<.0001*
Malocclusion	<.0001*
ABO Certified (Yes vs No)	0.003*
Years in Practice	0.0002*
Gender	0.0001*

\* Indicates significant at 0.05 level (Tukey's adjusted)



**Figure 8.** Additional Treatment Time for Orthodontists by Years in Practice

**Table 16.** Pairwise Comparison of Extension of Treatment Length by Years in Practice for Orthodontists

<b>Years in Practice</b>	<b>Comparison</b>	<b>Estimated Difference</b>	<b>SE</b>	<b>P-Value</b>
1-10	11-20	-0.1103	0.1418	0.9367
1-10	21-30	-0.6171	0.1506	0.0006 *
1-10	31-40	-0.5277	0.1687	0.0169 *
1-10	41+	-0.3193	0.2487	0.7014
11-20	21-30	-0.5068	0.1417	0.0039 *
11-20	31-40	-0.4174	0.1598	0.0716
11-20	41+	-0.209	0.2411	0.9087
21-30	31-40	0.08942	0.1671	0.9836
21-30	41+	0.2978	0.2458	0.7449
31-40	41+	0.2084	0.2555	0.9256

\* Indicates significant at 0.05 level (Tukey’s adjusted)

*Parents*

After adjusting for treatment time, compliance, and malocclusion for only parents, the age of a child was significantly associated with extension of treatment time (Table 17). Parents of children 14 years and older would extend treatment longer than parents of 8 to 13 year olds, 7.33 months compared to 6.95 months, respectively. The number of months that their child had been in treatment and the gender of both parents and children were not associated with extension of treatment length.

**Table 17.** Factors Associated with Parents for Extension of Treatment

<b>Effect</b>	<b>P-value</b>
Time in Treatment	<.0001*
Compliance	0.2357
Malocclusion	<.0001*
Gender: Guardian	0.3299
Age of Child	0.0136*
Gender: Child	0.0776
Child: Months Treatment Completed	0.9797

\* Indicates significant at 0.05 level (Tukey’s adjusted)

## **Ideal Compared to Actual Treatment Length**

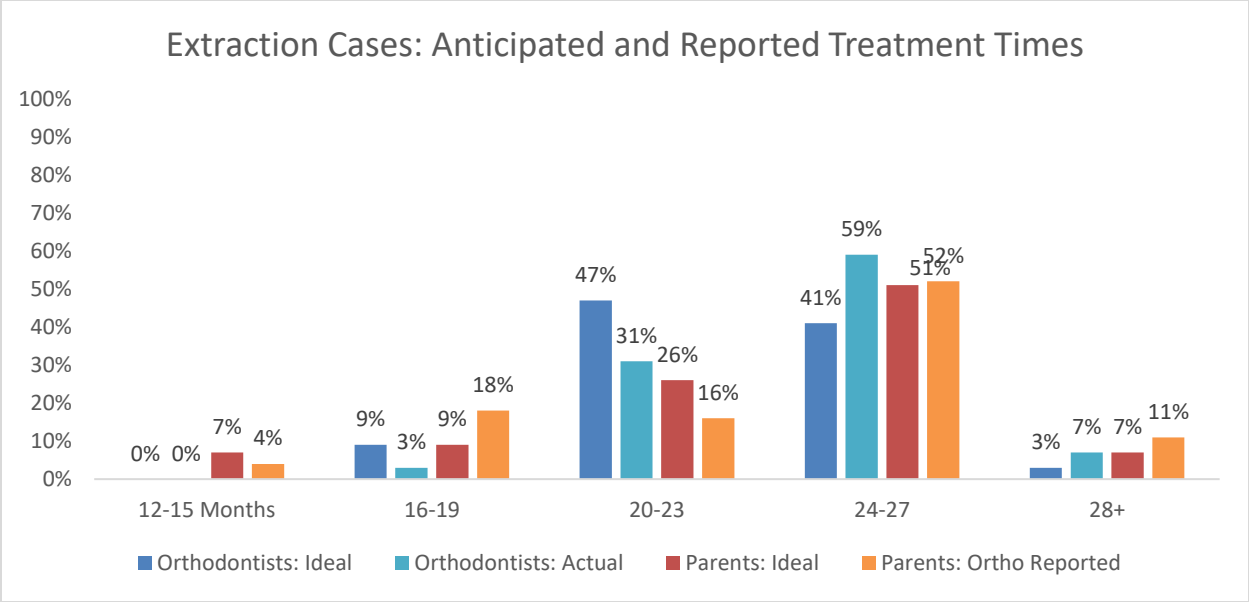
In the following sections, ideal refers to the perceived amount of time a patient should be in orthodontic treatment. Actual treatment time refers to the number of months necessary to complete orthodontic treatment.

Both orthodontists and parents reported their perceived ideal treatment times (Table 18). Additionally, each orthodontist was asked to self-report his/her actual average treatment time for both extraction and non-extraction cases. Significant differences were found between orthodontists' treatment times for extraction cases compared to non-extraction cases for both ideal ( $p\text{-value}<0.0001$ ) and actual treatment length ( $p\text{-value}<0.0001$ ) (Table 18). Parents were asked to recall the length of treatment time their orthodontist estimated during the initial consultation, which is henceforth defined as the orthodontist-reported treatment time. Since all parents in this study had a child that was currently in orthodontic treatment, parents were not able to provide the actual time needed to complete their child's comprehensive treatment. Therefore, the parents' orthodontist-reported treatment time was used to represent the parents' perspective for actual treatment length. For parents, extraction and non-extraction information were determined by asking each parent if their child had extractions of permanent teeth as part of orthodontic treatment (Figure 9, Figure 10).

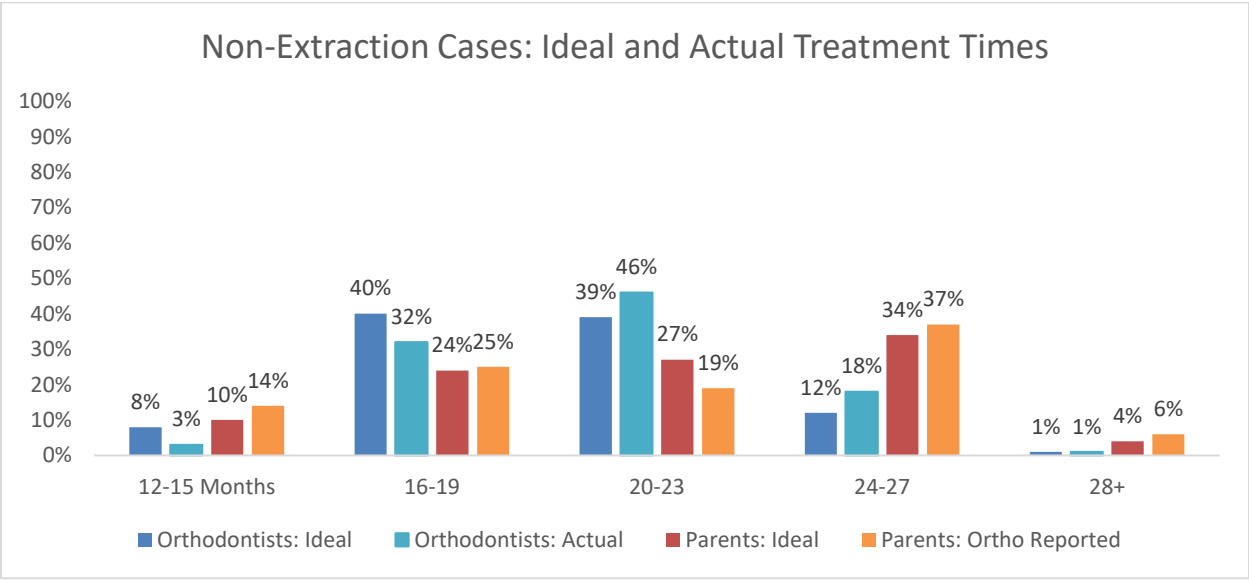
**Table 18.** Orthodontist and Parent Response for Ideal and Actual Treatment Times

<b>Orthodontist</b>			<b>P-value<sup>a</sup></b>
<b>Ideal Treatment Times (months)</b>	<b>Extraction Cases: n (%)</b>	<b>Non-Extraction Cases: n (%)</b>	<b>&lt;0.0001</b>
12-15	1 (0%)	19 (8%)	
16-19	20 (9%)	91 (40%)	
20-23	108 (47%)	90 (39%)	
24-27	95 (41%)	28 (12%)	
28+	8 (3%)	2 (1%)	
<b>Actual Treatment Times (months)</b>	<b>Extraction Cases: n (%)</b>	<b>Non-Extraction Cases: n (%)</b>	<b>&lt;0.0001</b>
12-15	0 (0%)	7 (3%)	
16-19	8 (3%)	74 (32%)	
20-23	71 (31%)	105 (46%)	
24-27	136 (59%)	42 (18%)	
28+	17 (7%)	2 (1%)	
<b>Parents</b>			
<b>Ideal Treatment Time (months)</b>	<b>Extraction Cases: n (%)</b>	<b>Non-Extraction Cases: n (%)</b>	<b>0.0542</b>
12-15	4 (7%)	18 (10%)	
16-19	5 (9%)	42 (24%)	
20-23	15 (26%)	47 (27%)	
24-27	29 (51%)	60 (34%)	
28+	4 (7%)	7 (4%)	
<b>Orthodontist-Reported Treatment Time (months)</b>	<b>Extraction Cases: n (%)</b>	<b>Non-Extraction Cases: n (%)</b>	<b>0.0618</b>
12-15	2 (4%)	24 (14%)	
16-19	10 (18%)	45 (25%)	
20-23	9 (16%)	33 (19%)	
24-27	29 (52%)	65 (37%)	
28+	6 (11%)	10 (6%)	

<sup>a</sup>Chi-squared test for differences between extraction and non-extraction cases



**Figure 9.** Ideal and Actual Treatment Times for Extraction Cases



**Figure 10.** Ideal and Actual Treatment Times for Non-Extraction Cases

Orthodontists reported significantly longer actual treatment times than what they believed was the ideal treatment duration for both extraction and non-extraction cases (Table 19). The average difference was 1.26 months for extraction cases (p-value<0.0001) and 0.93 months for non-extraction (p-value<0.0001) (Table 20, Table 21).

There were also significant differences between what the parents reported their orthodontist stated compared to both the orthodontists' ideal and actual times (p-value<0.0001). In general, the parents' orthodontist-reported treatment times were longer than the treatment times that the orthodontists stated (Table 21). The only exception was for extraction cases; orthodontists stated actual treatment times 0.86 months longer than the parents' orthodontist-reported times, though the difference was not statistically significant (p-value=0.1375). Orthodontists' ideal treatment for non-extraction was significantly shorter by 1.51 months than parents' orthodontist-reported treatment times (p-value=0.0004).

The difference between parents' perception of ideal treatment length and the time initially stated by their child's orthodontist (orthodontist-reported treatment time) was not significant for either extraction or non-extraction cases (p-value=0.3764 and p-value=0.3907, respectively).

**Table 19.** Comparison of Orthodontists and Parents Perception of Ideal and Actual Reported Treatment Times

Comparison	P-value <sup>a</sup>	
	Extraction Cases	Non-Extraction Cases
Ortho: Actual vs Ideal	<0.0001	0.024
Ortho Ideal vs Parents Ortho-Reported	<0.0001	<0.0001
Ortho Actual vs Parents Ortho-Reported	<0.0001	<0.0001
Parents: Ideal vs Ortho-Reported	0.3764	0.3907
Parents Ideal vs Ortho Actual	0.0005	<0.0001

<sup>a</sup>from Chi-Squared test

**Table 20.** Average Treatment Times (Actual, Ideal) by Respondent in Months

<b>Average Treatment Times (in months)</b>	<b>Extraction Cases (mean ± SD)</b>	<b>Non-Extraction Cases (mean ± SD)</b>
<b>Orthodontist</b>		
Actual Treatment Times	24.29 ± 2.62	20.77 ± 3.18
Ideal Treatment Times	23.03 ± 2.85	19.81 ± 3.37
<b>Parents</b>		
Orthodontist-Reported Treatment Time	23.43 ± 4.10	21.32 ± 4.73
Ideal Treatment Time	23.18 ± 3.99	21.41 ± 4.32

**Table 21.** Comparison of Average Treatment Times (Actual, Ideal) between Orthodontists and Parents

<b>Comparison</b>	<b>Mean Difference (months), P-value<sup>β</sup></b>	
	<b>Extraction Cases</b>	<b>Non-Extraction Cases</b>
Ortho: Actual vs Ideal	1.26, <0.0001	0.93, <0.0001
Ortho Ideal vs Parents Ortho-Reported	-0.39, 0.4989	-1.51, 0.0004
Ortho Actual vs Parents Ortho-Reported	0.86, 0.1375	-0.55, 0.1836
Parents: Ideal vs Ortho-Reported	-0.21, 0.6352	0.07, 0.8041
Parents Ideal vs Ortho Actual	-1.11, 0.0503	0.64, 0.1016

<sup>β</sup>from t-test

## DISCUSSION

### **Demographics**

The study consisted of parallel surveys that investigated orthodontists' and parents' perception of occlusion in the AP dimension. The 23% response rate for orthodontists and 32% response rate for parents was similar to response rates for mailed surveys to dentists and orthodontists in recent studies.<sup>35, 36</sup> Hardigan et al. found response rates were highest among dentists at 26% if surveys were mailed.<sup>35</sup> Best et al. reported similar response rates of 37% for orthodontists and 23% for general dentists.<sup>36</sup> The percentages of orthodontist respondents that were male (78%) and female (22%) were similar to the reported percentages of 73% male and 27% female from the 2016 membership of the American Association of Orthodontists.<sup>37</sup> Kleim et al. reported a distribution of 81% male and 19% female orthodontists.<sup>38</sup> Additionally, Kleim et al. found the median years of practice was 22, which corroborate the response characteristic of this study regarding 79% of respondents have practiced less than 30 years.

For parents, the distribution of sex and age was comparable to that of the parents included in a previous survey by Uribe et al.<sup>8</sup> The larger proportion of females that completed the survey indicates mothers are more likely to wait in the office during their child's orthodontic appointment, as surveys were administered to parents in-office.

### **Class I Occlusion**

Angle first introduced the classification system for occlusal relationships.<sup>39</sup> Andrews added that while ideal occlusion involves more than the first molar relationship, the first key presented in his classic paper of a normal, ideal occlusion was Class I molar relationship.<sup>40</sup>



Without the presence of a tooth-size discrepancy, establishing Class I occlusion with proper alignment within both dental arches will also idealize the overbite and overjet. Both orthodontists and parents rated Class I with the highest rated VAS score, indicating a strong preference for orthodontic treatment finishing in ideal Class I occlusion.

The advantages of Class I occlusion have been discussed in the literature. English et al. demonstrated the benefit of Class I occlusion for providing more effective masticatory function compared to Class II and Class III occlusions in the ability to break down food particles.<sup>41</sup> However, little evidence beyond masticatory function supports a clear health advantage of a Class I occlusion over Class II and Class III occlusions. Turp et al. found no correlation between temporomandibular disorders to type of occlusion.<sup>42</sup> Additionally, Geiger reported no difference in periodontal disease for different Angle Classifications.<sup>43</sup>

The findings of the current study suggest another benefit of Class I occlusion is that both orthodontists and parents view Class I as the most acceptable treatment outcome, which may also represent an esthetic preference. Previous studies have indicated that esthetics is one of the main motivations for both patients and parents to seek orthodontic treatment.<sup>12, 15, 44-46</sup> Daniels et al. found that both patients (93.4%) and parents (91.6%) ranked esthetics as the primary reason for pursuing orthodontic treatment.<sup>15</sup> Prabakaran et al. identified esthetics as the most important factor for patients and the second most important factor for parents to seek orthodontic treatment.<sup>44</sup> Since esthetic improvements motivate parents and patients to seek orthodontic treatment, attainment of an ideal Class I occlusion provides the most esthetic outcome and may best address the patient's or parent's chief concerns.

## **Respondent Type**

### *Orthodontist*

The number of ABO certified respondents (38%) was roughly equal to the national average. ABO certification did not produce a difference in scoring treatment outcomes, indicating board certification status does not influence orthodontists' rating of acceptability of treatment outcomes. Since all orthodontist must attend a graduate residency program, the lack of difference between certified and non-certified orthodontist is likely because all graduate programs educate orthodontists to have the highest standards. While no difference was seen between certified and non-certified orthodontists, the authors recognize the positive value of board certification, which includes the commitment to achieving the highest level of personal accomplishment within the specialty.

The only significant differences between orthodontists were sex and the number of years in practice. Since the proportion of female respondents was lower than males, the difference in VAS scores may be a result of a smaller sample size, as the standard error for average VAS scores for females was close to double that of males (0.81 and 0.44, respectively). However, the larger variation with female orthodontists was also seen in a study by Parekh et al. that found female orthodontists utilized more of the scale when rating on a VAS.<sup>47</sup> Possibly, the female orthodontists were more discerning when they completed a VAS, or male orthodontists on average were more consistent in scoring a VAS. Regardless, the fact a statistical difference was found between male and female orthodontists despite females having a larger variation likely represented a true difference. Regarding the intervals for years in practice, once adjusted for multiple comparisons, no statistical difference was seen in the number of years an orthodontist has practiced.

Orthodontists were able to statistically differentiate each of the occlusal variations with a trend toward scoring Class II occlusions more favorably than Class III occlusions. Since the prevalence of Class II malocclusions are around 50% of the U.S. population compared to around 5% for Class III malocclusions, orthodontists treat more Class II malocclusions.<sup>48</sup> The greater frequency of treatment for Class II malocclusions may explain why orthodontists scored Class II malocclusions more acceptable than Class III malocclusions. With more familiarity in treating Class II malocclusions, orthodontists may have greater confidence in correcting this malocclusion, which led to overall higher VAS scores. In conjunction to the molar/canine classification, the overjet may have influenced how orthodontists rated Class II and Class III malocclusions. The slightly increased overjet in CI II:2 and CI II:3 was scored more acceptable than the end-to-end anterior bite represented by CI III:2 and the anterior crossbite in CI III:3.

### *Parents*

Parents did not statistically differentiate between CI I and CI III:1, indicating that parents may not see a difference between these two malocclusions. The inability for a layperson to notice a 1 mm difference has been documented in previous studies.<sup>11,13</sup> Kokich et al. found that laypeople did not reach a threshold for finding symmetric alterations of maxillary anterior teeth unesthetic until there was a 2 mm discrepancy.<sup>13</sup> For unilateral crown length asymmetries, Kokich et al. found the threshold was 1.5 mm for laypeople.<sup>11</sup> However, in the current study parents were able to notice 1 mm changes in the AP dimension for all other occlusal relationships presented. While parents were able to notice 1 mm changes, the range of VAS scores was greater for the orthodontists (range = 25.9 to 93.9) compared to the parents (range = 40.9 to 80.7).

Compared to orthodontists, parents rated CI III:2 more acceptable than CI II:2. While the absolute value of the 2 mm deviation from CI I was the same, parents responded differently depending if the deviation was anterior or posterior. One explanation is that parents may have noticed the overjet relationship. These results, along with the fact parents did not differentiate between CI I and CI III:1, suggest that parents viewed less overjet as more esthetic. However, CI III:3 was found to be the least acceptable treatment outcome. Likely, the presence of an anterior crossbite accounted for the lowest VAS scores. Another possible reason Class III occlusions trended more acceptable than Class II occlusions is that parents may think an ideal bite involves the anterior teeth occluding edge to edge.

## **Compliance**

For the purpose of this study compliance referred to patients who attended orthodontic appointments on time, had great oral hygiene, did not break brackets, and followed the orthodontist's instructions regarding foods to avoid and wearing elastics. Parents and orthodontists found noncompliant patients' treatment outcomes more acceptable than treatment outcomes with adequate patient compliance. Both orthodontists and parents may have rated noncompliant treatment outcomes less objectively and more acceptable because the outcomes described were achieved without adequate patient compliance. In other words, the outcomes from compliant patients may have been scored more stringently.

Riedman et al. found similar results when objective orthodontists' assessments were compared to the subjective rating by patients. Results revealed discrepancies in assessments, with the patients' ratings of outcomes more positive than the orthodontists' ratings. Furthermore, when

comparing a group of ideal treatment to a group of compromised treatment, a high level of patient satisfaction was attained with a shorter treatment duration and with less orthodontic appliances in the compromised group.<sup>14</sup>

### **Treatment Length: 18 month versus 24 month**

While 18 and 24 months may be frequently considered as average duration for treatment, these time points are not supported in the literature.<sup>1-5</sup> Thus, the selection of 18 months and 24 months arbitrarily represented two time points that are commonly discussed as expected treatment lengths. The orthodontists' ideal treatment times were remarkably close at 19.81 months for non-extraction cases and 23.03 months for extraction.

If the percentage of orthodontic cases involving extractions decreases, it is possible that overall treatment duration may decrease. Proffit analyzed the rate of extractions at the University of North Carolina from the 1950s to the 1990s, finding a cyclical pattern in the frequency of extractions with the rate of extractions around 30% in 1953 and 1993.<sup>49</sup> More recently, Jackson et al. looked at extraction rates for the first decade of the 21<sup>st</sup> century at the University of North Carolina and found extraction rates decreased from 37.4% in 2000 to 22.9% in 2011.<sup>50</sup> According to the 2014 report by Keim et al., the frequency of extractions cases in private practice has steadily decreased from 35% of cases in 1986 to 15% of cases in 2014.<sup>38</sup> However, while extraction rates have decreased, this does not necessarily equate to decreased treatment lengths. For instance, treatment duration could actually increase if an orthodontist is committed to treating with non-extraction therapy when a patient has severe crowding, large overjet, anterior open bite, or a skeletal discrepancy.

Analyzing treatment length by respondent type and case acceptability, there was a statistical significant difference between orthodontists and parents' perception of treatment outcomes after 18 months of treatment. Yet, the statistical significance was not clinically relevant due to the small VAS difference of three points on a 100 point scale.

### **Extension of Treatment**

Overall parents were willing to extend treatment longer than orthodontists. This may be due to the lack of knowledge by parents to the potential harm that may develop when braces are left on too long (root resorption, white spot lesions, and periodontal issues). Another potential reason for parents' willingness to extend treatment is that parents do not have the same level of knowledge regarding biology of tooth movement and biomechanics compared to orthodontists. Additionally, parents are normally the financially responsible party for orthodontic treatment. Since there is a monetary investment by the parents, they may be willing to extend treatment to achieve a more ideal result. Regardless of the reason why parents are willing to extend orthodontic treatment longer than orthodontists, orthodontists should utilize their expertise to inform parents and patients when the risks of continuing orthodontic treatment outweighs the benefits.

The results of this study may help clinicians predict the amount of time parents will prolong treatment to achieve a more ideal treatment outcome. Often ideal Class I classification at the canines and molars is a goal of orthodontic treatment. During the detailing and finishing phase of treatment, achieving the perfect, socked-in classification can be challenging. The difficulty of achieving ideal Class I occlusion is further complicated in cases where patients are burned out from treatment and are noncompliant with elastic wear. Regardless of the level of patient

compliance, parents are willing to extend treatment for an additional 7 months, while orthodontists will extend treatment 4.4 months for noncompliant patients up to 6 months for compliant patients. The difference in orthodontists' extension of treatment between noncompliant and compliant patients demonstrates orthodontists are more willing to terminate treatment with poor compliance.

Additionally, regardless of AP discrepancy, parents would extend treatment 2 months longer than orthodontists. When the AP discrepancy is within 1 mm from ideal, parents would extend treatment 5-6 months to achieve ideal Class I occlusion, which on average is 2-3 months longer than orthodontists. In the absence of any factors that may cause deleterious effects to the patient, orthodontists may want to consider extending treatment for an additional 2-3 months longer than they normally would, if needed to achieve a more ideal treatment outcome, as parents did not want to compromise treatment outcomes and were not concerned with prolonged treatment durations.

CI III:3 was viewed as the malocclusion that both orthodontists and parents were willing to extend treatment the longest (8.7 months and 9.4 months, respectively). Since this malocclusion was also rated the least acceptable malocclusion, both parents and orthodontists may have recognized the difficulty of correcting a 3 mm AP discrepancy with an anterior crossbite. Interestingly, orthodontists were willing to spend 1.8 more months correcting CI III:3 than CI II:3 despite both malocclusions having a 3 mm AP discrepancy. Again, this may be a result of a greater prevalence of Class II malocclusions leading to greater confidence by the orthodontist to predictably correct Class II relationships. Alternatively, the anterior crossbite present with the CI III:3 malocclusion may account for the increase in treatment duration. Alleviating an anterior crossbite may involve treatment mechanics to temporarily disarticulate the bite, and therefore take more time to correct.

When comparing 18 months of treatment versus 24 months of treatment, significant differences were found between orthodontists and parents at both time points, between the parents' responses at both time points, and between the orthodontists' responses at both time points (Table 14). However, the orthodontists' assessment at 18 months compared to the orthodontists' assessment at 24 months only differed by an estimated difference of 0.3 months, which is not clinically relevant. The difference between the parents' responses at 18 months and 24 months was only 0.5 months, which is not clinically relevant.

The significant differences found among orthodontists' willingness to extend treatment are not clinically relevant. The 0.3 months difference between ABO and non-ABO certified orthodontists and 0.6 months difference seen between orthodontists in the first 10 years of practice and orthodontists practicing 21 to 30 years are clinically negligible.

### **Expected vs Actual Treatment Times**

Orthodontists slightly underestimated their ideal treatment time compared to their actual treatment time, with mean differences of 1.26 months for extraction cases and 0.93 months for non-extraction cases. While the orthodontists predicted slightly shorter treatment times than are realized, the statistical difference has little clinical relevance.

Parents stated the ideal treatment time to be 21.41 months for non-extraction cases and 23.18 months for extraction cases. Uribe et al. surveyed 200 parents who believed treatment should last more than 24 months; however, 94% of the parents wished for treatment to last less than 24 months.<sup>8</sup> Parents' expectation regarding treatment length was consistent with what parents recalled their orthodontist initially estimating for treatment length. Two possibilities exist to



explain the high level of consistency. One, parents listen during the consultation with the orthodontist and believe the amount of time the orthodontist states is accurate. Or, parents that completed orthodontic treatment during their adolescence may relate the time needed to complete their orthodontic treatment as a reference for the ideal treatment length. In other words, the parents' past experience completing orthodontic treatment may influence their current perception of treatment time. Fink and Smith found the average length of treatment in 1992 was 23.1 months.<sup>1</sup> Alger reported an average treatment length of 22.0 months in 1988.<sup>51</sup> With 56% of the parents younger than 45 years old, it is likely that if they completed orthodontic treatment as an adolescent, their orthodontic treatment would have been completed during the late 1980s or early 1990s and likely fallen in the range of treatment duration listed above.

### **Limitations**

The study design introduces several potential biases, including: nonrespondent bias, recall bias, obsequiousness bias, and attention bias. The design of using digital models may have decreased the potential of introducing factors associated with the shades of teeth and gingiva. However, while orthodontists are accustomed to viewing study casts, parents may have had difficulty analyzing the digital images. The significant differences found with little clinical relevance are likely due to large sample size and small variability in answers.

## CONCLUSIONS

- Orthodontists and parents view orthodontic treatment outcomes in the AP dimension differently.
- Class I occlusion is rated as the most acceptable outcome by both orthodontist and parents.
- Orthodontists and parents do not differ in acceptance of treatment outcomes when comparing the same result at 18 months versus 24 months.
- Parents are willing to extend treatment duration longer than orthodontists.

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## APPENDICES

### Appendix 1. Survey to Orthodontists - Version A



You are invited to participate in a research study investigating the acceptability of orthodontic treatment outcomes. All responses are anonymous and no personal identifiers will be collected. You may stop taking the questionnaire at any point and withdraw from the study. The survey should take 5 – 10 minutes to complete. If you elect to participate, please read and follow the instructions below. Thank you for your participation.

#### Instructions:

The following survey contains 8 sets of images. Each set contains 3 views (right, center, left) of digital models from an orthodontic patient. *For each set of images, please imagine that this is a patient that you are treating.* Depending on the image, the patient has been in active treatment for **either 18 or 24 months.**

You will be asked to evaluate each image as the treatment outcome for a compliant patient and a noncompliant patient. For the purpose of this study, **compliance** refers to patients who: attend orthodontic appointments on time, have great oral hygiene, do not break brackets, and follow the orthodontist's instructions regarding foods to avoid and wearing elastics.

Please mark on the lines below each image indicating how acceptable you rate the present result.

Once you have marked the line, please immediately answer the question directly below the scale and proceed to the next set of images/questions. After you have evaluated all images, please answer all of the remaining questions to the best of your ability.

Once you have completed the survey, please place the survey packet in the return envelope provided.

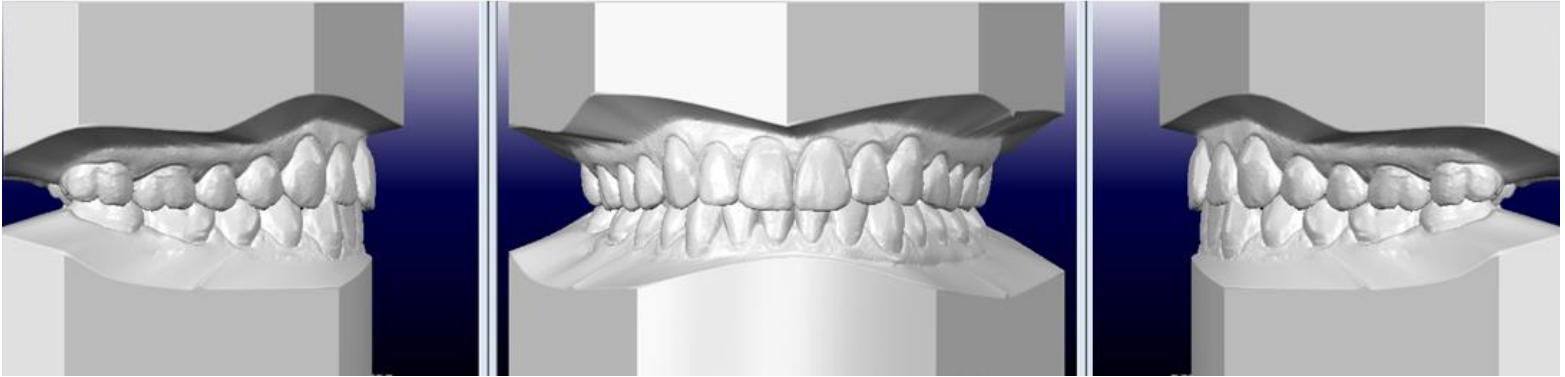
If you have any further questions, you may contact the research team at:

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1. The models shown below represent a patient that has been in treatment for **24 months**.



I. Please indicate on the scale below how acceptable you find the above treatment outcome for a **compliant** patient after **24 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

A) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **compliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

II. Please indicate on the scale below how acceptable you find the above treatment outcome for a **noncompliant** patient after **24 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

B) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **noncompliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

2. The models shown below represent a patient that has been in treatment for **18 months**.



I. Please indicate on the scale below how acceptable you find the above treatment outcome for a **compliant** patient after **18 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

A) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **compliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

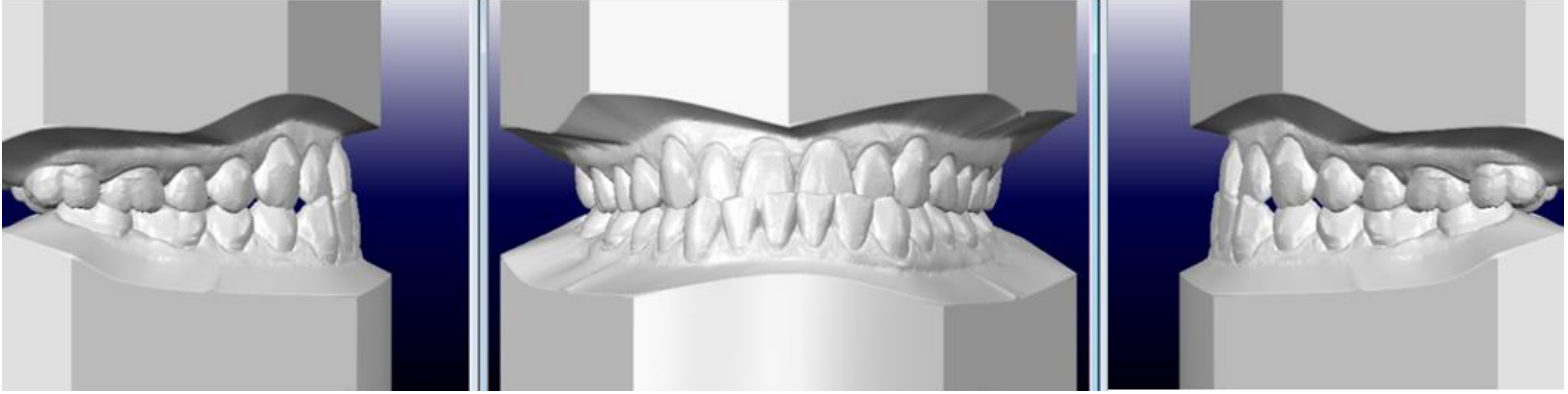
II. Please indicate on the scale below how acceptable you find the above treatment outcome for a **noncompliant** patient after **18 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

B) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **noncompliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

3. The models shown below represent a patient that has been in treatment for **18 months**.



I. Please indicate on the scale below how acceptable you find the above treatment outcome for a **compliant** patient after **18 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

A) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **compliant** patient?

- 0-3 months       4-7 months       8-11 months       12+ months

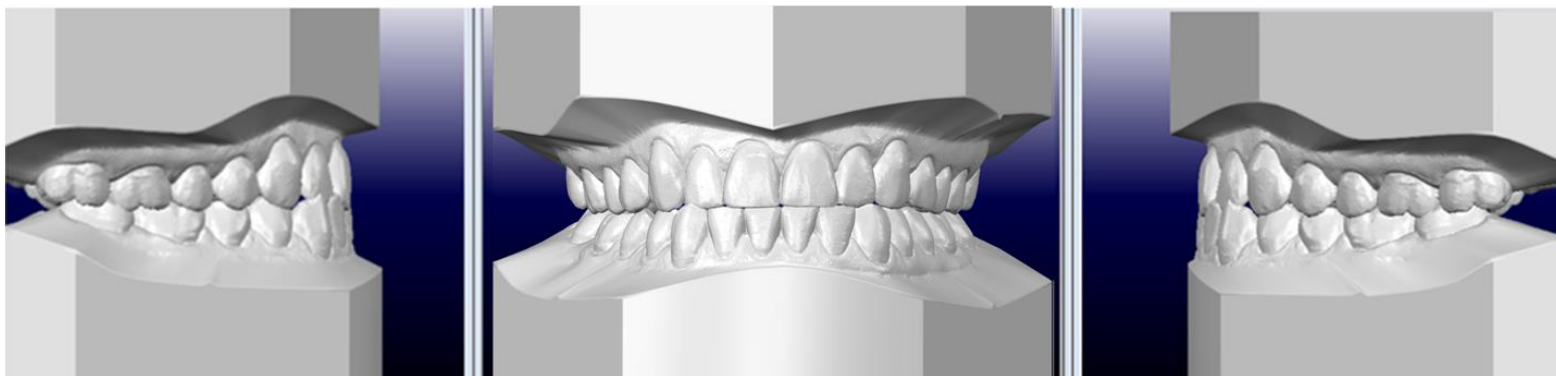
II. Please indicate on the scale below how acceptable you find the above treatment outcome for a **noncompliant** patient after **18 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

B) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **noncompliant** patient?

- 0-3 months       4-7 months       8-11 months       12+ months

4. The models shown below represent a patient that has been in treatment for **18 months**.



I. Please indicate on the scale below how acceptable you find the above treatment outcome for a **compliant** patient after **18 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

A) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **compliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

II. Please indicate on the scale below how acceptable you find the above treatment outcome for a **noncompliant** patient after **18 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

B) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **noncompliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

5. The models shown below represent a patient that has been in treatment for **18 months**.



I. Please indicate on the scale below how acceptable you find the above treatment outcome for a **compliant** patient after **18 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

A) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **compliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

II. Please indicate on the scale below how acceptable you find the above treatment outcome for a **noncompliant** patient after **18 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

B) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **noncompliant** patient?

0-3 months       4-7 months       8-11 months       12+ months



6. The models shown below represent a patient that has been in treatment for **24 months**.



I. Please indicate on the scale below how acceptable you find the above treatment outcome for a **compliant** patient after **24 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

A) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **compliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

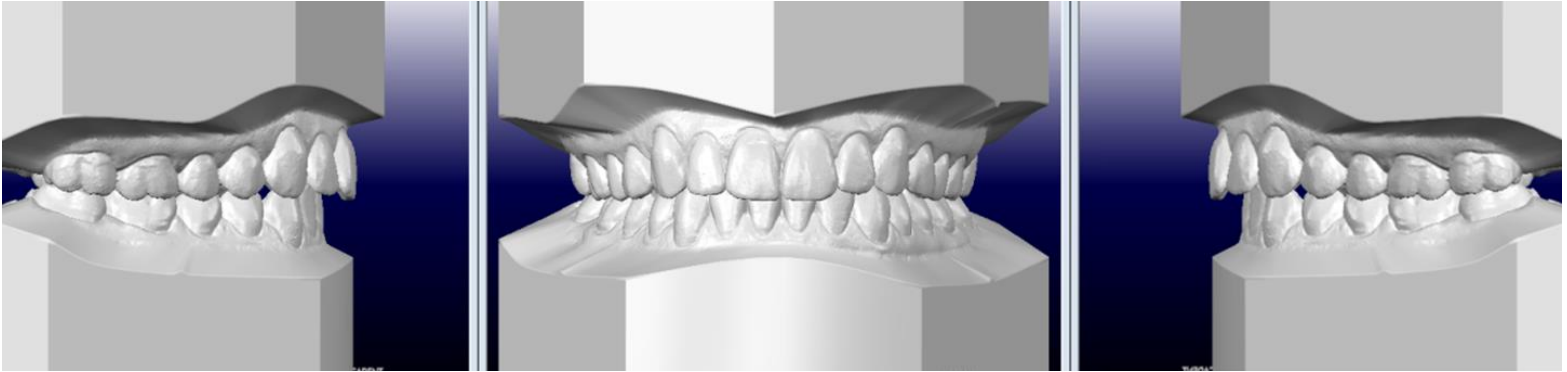
II. Please indicate on the scale below how acceptable you find the above treatment outcome for a **noncompliant** patient after **24 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

B) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **noncompliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

7. The models shown below represent a patient that has been in treatment for **24 months**.



I. Please indicate on the scale below how acceptable you find the above treatment outcome for a **compliant** patient after **24 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

A) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **compliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

II. Please indicate on the scale below how acceptable you find the above treatment outcome for a **noncompliant** patient after **24 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

B) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **noncompliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

8. The models shown below represent a patient that has been in treatment for **24 months**.



I. Please indicate on the scale below how acceptable you find the above treatment outcome for a **compliant** patient after **24 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

A) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **compliant** patient?

- 0-3 months       4-7 months       8-11 months       12+ months

II. Please indicate on the scale below how acceptable you find the above treatment outcome for a **noncompliant** patient after **24 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

B) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **noncompliant** patient?

- 0-3 months       4-7 months       8-11 months       12+ months

Please answer the following questions.

1) How old are you?

- 25 – 34 yo     35 – 44 yo     45 – 54 yo     55 – 64 yo     65+ yo

2) Please check the box with your gender:

- Male                       Female

3) Are you currently ABO certified?

- Yes                       No

4) How many years have you practiced orthodontics?

- 1 – 10               11 – 20               21 – 30               31 – 40               41 +

5) In months, how long is your average treatment time?

Extraction Case:     12 – 15     16 – 19     20 – 23     24 – 27     28 +

Non-extraction Case:  12 – 15     16 – 19     20 – 23     24 – 27     28 +

6) In months, ideally, how long do you think a patient should be in treatment?

Extraction Case:     12 – 15     16 – 19     20 – 23     24 – 27     28 +

Non-extraction Case:  12 – 15     16 – 19     20 – 23     24 – 27     28 +

7) Comments:

## Appendix 2. Survey to Parents - Version B



You are invited to participate in a research study investigating the acceptability of orthodontic treatment outcomes. All responses are anonymous and no personal identifiers will be collected. You may stop taking the questionnaire at any point and withdraw from the study. The survey should take 5 – 10 minutes to complete. If you elect to participate, please read and follow the instructions below. Thank you for your participation.

### Instructions:

The following survey contains 8 sets of images. Each set contains 3 views (right, center, left) of digital models from an orthodontic patient. *For each set of images, please imagine that this is your child's teeth.* Depending on the image, the patient has been in active treatment for **either 18 or 24 months.**

You will be asked to evaluate each image as the treatment outcome for a compliant patient and a noncompliant patient. For the purpose of this study, **compliance** refers to patients who: attend orthodontic appointments on time, have great oral hygiene, do not break brackets, and follow orthodontist's instructions regarding foods to avoid and wearing elastics.

Please mark on the lines below each image indicating how acceptable you rate the present result.

Once you have marked the line, please immediately answer the question directly below the scale and proceed to the next set of images/questions. After you have evaluated all images, please answer all of the remaining questions to the best of your ability.

Once you have completed the survey, please return this packet to the office staff member that handed it to you.

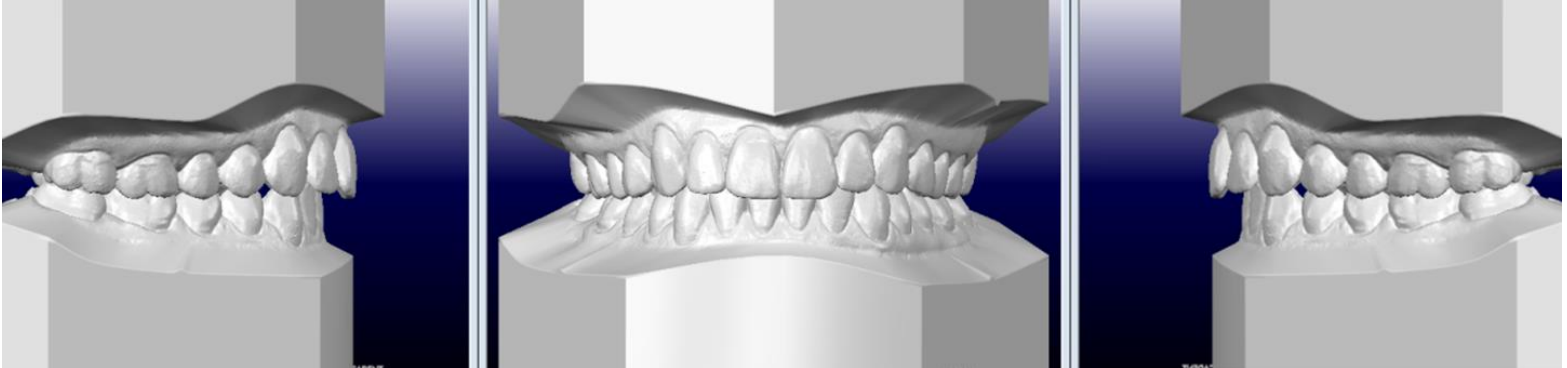
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1. The models shown below represent a patient that has been in treatment for **18 months**.



I. Please indicate on the scale below how acceptable you find the above treatment outcome for a **compliant** patient after **18 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

C) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **compliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

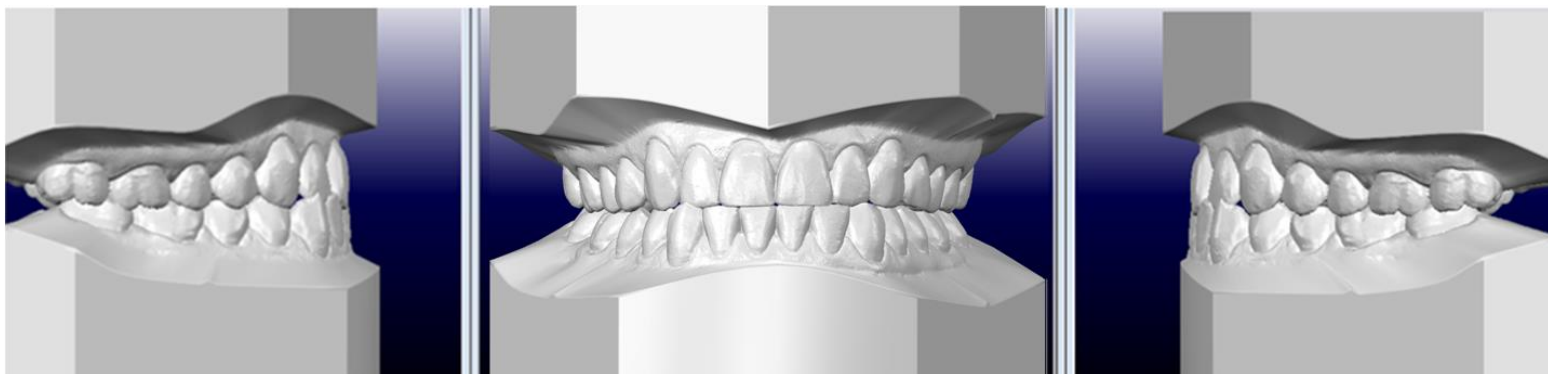
II. Please indicate on the scale below how acceptable you find the above treatment outcome for a **noncompliant** patient after **18 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

D) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **noncompliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

2. The models shown below represent a patient that has been in treatment for **24 months**.



I. Please indicate on the scale below how acceptable you find the above treatment outcome for a **compliant** patient after **24 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

C) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **compliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

II. Please indicate on the scale below how acceptable you find the above treatment outcome for a **noncompliant** patient after **24 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

D) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **noncompliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

3. The models shown below represent a patient that has been in treatment for **18 months**.



I. Please indicate on the scale below how acceptable you find the above treatment outcome for a **compliant** patient after **18 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

A) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **compliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

II. Please indicate on the scale below how acceptable you find the above treatment outcome for a **noncompliant** patient after **18 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

B) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **noncompliant** patient?

0-3 months       4-7 months       8-11 months       12+ months



4. The models shown below represent a patient that has been in treatment for **24 months**.



I. Please indicate on the scale below how acceptable you find the above treatment outcome for a **compliant** patient after **24 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

A) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **compliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

II. Please indicate on the scale below how acceptable you find the above treatment outcome for a **noncompliant** patient after **24 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

B) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **noncompliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

5. The models shown below represent a patient that has been in treatment for **24 months**.



I. Please indicate on the scale below how acceptable you find the above treatment outcome for a **compliant** patient after **24 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

A) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **compliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

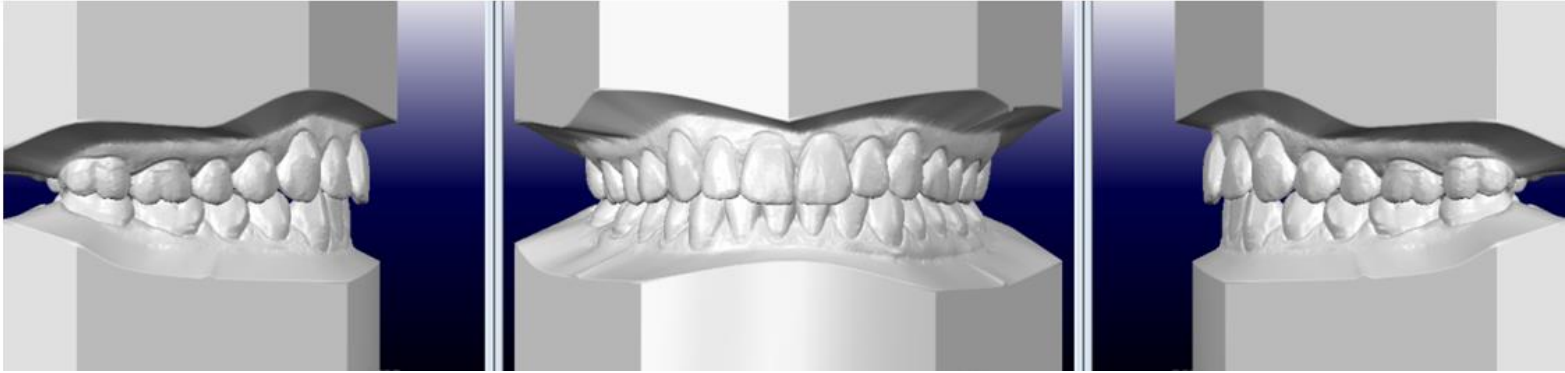
II. Please indicate on the scale below how acceptable you find the above treatment outcome for a **noncompliant** patient after **24 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

B) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **noncompliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

6. The models shown below represent a patient that has been in treatment for **24 months**.



I. Please indicate on the scale below how acceptable you find the above treatment outcome for a **compliant** patient after **24 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

A) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **compliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

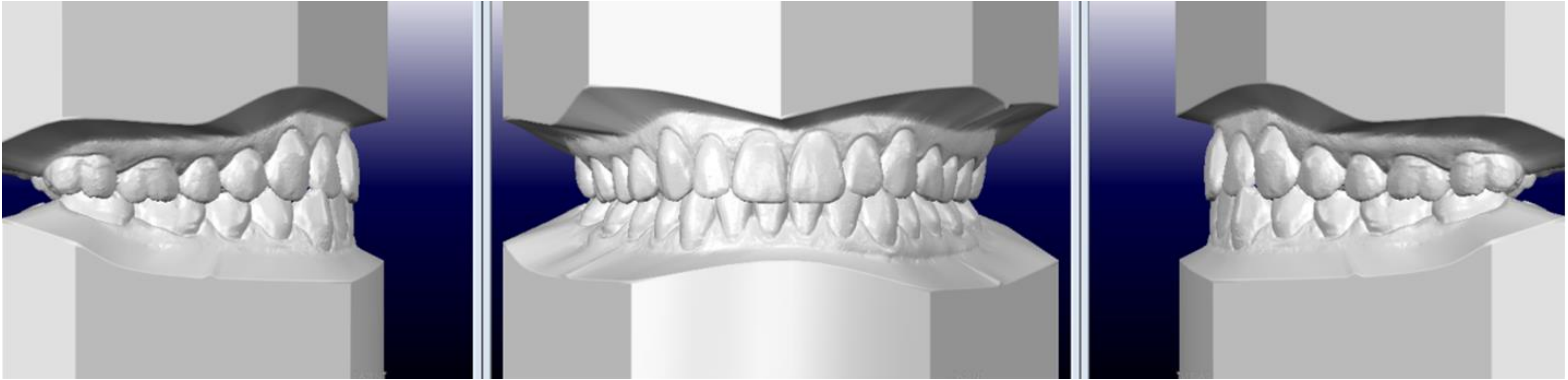
II. Please indicate on the scale below how acceptable you find the above treatment outcome for a **noncompliant** patient after **24 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

B) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **noncompliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

7. The models shown below represent a patient that has been in treatment for **18 months**.



I. Please indicate on the scale below how acceptable you find the above treatment outcome for a **compliant** patient after **18 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

A) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **compliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

II. Please indicate on the scale below how acceptable you find the above treatment outcome for a **noncompliant** patient after **18 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

B) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **noncompliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

8. The models shown below represent a patient that has been in treatment for **18 months**.



I. Please indicate on the scale below how acceptable you find the above treatment outcome for a **compliant** patient after **18 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

A) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **compliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

II. Please indicate on the scale below how acceptable you find the above treatment outcome for a **noncompliant** patient after **18 months** of treatment.

Least Acceptable 0 \_\_\_\_\_ 100 Most Acceptable

B) How many additional months would you be willing to continue orthodontic treatment to achieve ideal results in a **noncompliant** patient?

0-3 months       4-7 months       8-11 months       12+ months

Please answer the following questions. For questions regarding your child, please select the response that represents your child that is currently completing orthodontic treatment. If you have multiple children currently in orthodontic treatment, please select the response that corresponds to your child that started treatment first.

1) How old are you?  
 25 – 34 yo       35 – 44 yo       45 – 54 yo       55 – 64 yo       65+ yo

2) Please check the box with your gender:  
 Male                       Female

3) How old is your child?  
 8 – 10 yo               11 – 13 yo               14 – 16 yo               17+ yo

4) Please check the box with your child’s gender:  
 Male                       Female

5) Please check the box with the type of orthodontic appliance your child has:  
 Braces                       Clear Aligners/Invisalign ®

6) Did your child have any adult teeth extracted as part of his/her orthodontic treatment?  
 Yes                       No

7) When your child started treatment, how many months did your orthodontist tell you treatment would take?  
 12 – 15               16 – 19               20 – 23               24 – 27               28 +

8) How many months has your child been in orthodontic treatment?  
 1 – 6                       7 – 12                       13 – 18                       19 – 24                       25 +

9) How many more months do you expect your child to be in braces/Invisalign ®?  
 1 – 6                       7 – 12                       13 – 18                       19 – 24                       25 +

10) Ideally, how many months do you think your child should be in braces/Invisalign ® from start to finish?  
 12 – 15               16 – 19               20 – 23               24 – 27               28 +

11) Comments:

## VITA

David Lindsey was born on April 30, 1987 to Ronald Lindsey and Fawn Kimura Lindsey in San Diego, California. However, he was raised in Los Alamitos, California along with his younger brother and sister, Michael and Kate, respectively. After his graduation from Los Alamitos High School in 2005, David received a Bachelor of Science Degree in Psychobiology with a Minor in Biomedical Research from the University of California, Los Angeles in June 2010. He completed his dental education at the University of California, Los Angeles School of Dentistry in 2015. David continued his advanced training at Virginia Commonwealth University, where he received a Certificate of Orthodontics and Masters of Science in Dentistry in 2017. He intends to begin private practice in the Central Coast of California.