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Factors influencing the outcomes of class II camouflage treatment

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FACTORS INFLUENCING THE OUTCOMES OF CLASS II CAMOUFLAGE TREATMENT

by

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A thesis submitted in partial fulfillment
of the requirements for the Master of
Science degree in Orthodontics
in the Graduate College of
The University of Iowa

May 2014

Thesis Supervisor: Professor Robert N. Staley

Graduate College
The University of Iowa
Iowa City, Iowa

CERTIFICATE OF APPROVAL

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MASTER'S THESIS

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This is to certify that the Master's thesis of

Tyler Carl Prestwich

has been approved by the Examining Committee
for the thesis requirement for the Master of Science
degree in Orthodontics at the May 2014 graduation.

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To Cole

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INTRODUCTION

The treatment of Class II malocclusions is a common challenge faced by orthodontists. There are currently three modes of treatment for this type of malocclusion – (1) growth modification, (2) camouflage, whereby tooth movement compensates for but does not correct the underlying skeletal problem, and (3) orthognathic surgery. In patients for whom growth has ceased, only the latter two options are available. For many of these patients, surgery is not a viable option because of medical or financial concerns. In these cases, camouflage therapy can be a successful method of treatment. While camouflage therapy can include the extraction of any combination of teeth, the first maxillary premolars are most often selected for this type of treatment, with the subsequent canine and incisor retraction serving to align the anterior segment and mask the underlying Class II skeletal pattern.

While 2 premolar extraction camouflage treatment can be successful, many times a compromised result is obtained such that the canines are not corrected to Class I or there exists spacing distal to the canines or excess overjet in the maxillary arch. Therefore, when diagnosing and treatment planning for Class II correction by camouflage, an understanding of any preexisting factors that may promote a good versus a compromised outcome would be helpful in ensuring a successful result at the end of treatment. Thus, we have conducted a retrospective evaluation of Class II camouflage cases treated to both successful and compromised finishes in an attempt to identify factors that may be used prospectively with future patients to more predictively achieve successful results. This study has the potential to significantly contribute to our understanding of the factors that lead to successful Class II camouflage treatment.

PURPOSES OF THIS STUDY

The Purposes of this study are:

1) To determine whether pre-existing occlusal factors are associated with the quality of finish.
2) To elucidate differences in occlusal factors for the different finish groups at the end of treatment.
3) To determine whether there are differences in the occlusal factors over the course of treatment.
4) To determine whether age of the patient and/or patient compliance affects the outcome of treatment.

LITERATURE REVIEW

The available literature regarding Class II camouflage treatment consists mainly of retrospective clinical studies that can be divided into two major groups: 1) descriptive articles examining the dentofacial effects of 2 premolar extraction therapy and 2) comparison studies that fall within one of three main categories. These categories include studies comparing 4 premolar extraction and non-extraction therapy, 2 premolar versus 4 premolar extraction therapy, and 2 premolar extraction therapy versus orthognathic surgery.

Studies describing the results of Class II camouflage treatment have examined the effect of premolar extraction and subsequent incisor retraction on soft tissue changes and profile evaluations based on cephalometric measurements. For example, Conley and Jernigan reported a 2.03 mm average maxillary lip retraction in Class II division 1 patients treated with upper premolar extraction (Conley and Jernigan 2006), and suggested that this treatment may be especially viable in patients with full upper lips and only a relative mandibular deficiency. Similarly, Tadic and Woods noted a wide range of individual response in lip behavior after upper premolar extraction and observed that these changes were most likely related to the preexisting morphology of the lips themselves (Tadic and Woods 2007). Other studies have surveyed the effects of Class II camouflage treatment on the facial skeleton and soft tissue and found analogous results including a deterioration in value in relation to A point, the upper incisor, and the upper lip to E plane with treatment (Demir, et al. 2005).

A majority of studies related to Class II camouflage therapy compare this mode of treatment with other options for correcting a skeletal Class II malocclusion, such as 4 premolar extraction and orthognathic surgery. Articles comparing 2 premolar versus 4 premolar extraction therapies indicate a better occlusal success rate with the 2 premolar extraction therapy. Specifically, Janson et al. reported a superior final canine anteroposterior position as well as overbite and overjet in the patients treated with 2 premolar extraction camouflage (Janson, Brambilla, et al. 2004). Interestingly, the authors later showed that while there were some differences in pre-treatment cephalometric values between the two groups, these differences did not affect the final occlusal success rates of the two treatments (Janson, Janson, et al. 2008).

Studies comparing the outcomes of Class II camouflage therapy with orthognathic surgery are focused mainly on post-treatment patient satisfaction and overall facial esthetics. One long-term follow-up study comparing patients who had been treated with orthodontic camouflage and patients treated with orthognathic surgery showed that patients' overall perceptions of outcomes were highly positive in both groups (Mihalik, Proffit and Phillips 2003). Cassidy et al. reported similar findings in their comparison of camouflage and surgery patients (Cassidy, et al. 1993). In a more thorough evaluation of patients treated with orthodontic camouflage alone or with orthognathic surgery, Proffit et al. showed that while both orthodontic treatment and surgical-orthodontic treatment improved the malocclusion as judged by dental casts, surgery resulted in greater reduction of overjet and greater improvement in most cephalometric skeletal, dental and soft tissue criteria (Proffit, Phillips and Douvartzidis 1992). Finally, in a cephalometric study aimed at evaluating the effects of different Class II treatment modalities, Kinzinger et al. reported that Class II camouflage treatment resulted in an increased nasolabial angle, but no other profile changes were noted (Kinzinger, Frye and Diedrich 2009). While a focus on facial esthetics in the literature is not misguided, the failure of many of these studies to highlight the final occlusal relationships obtained after treatment renders them incomplete, since obtaining occlusal harmony and proper interdigitation of the dentition is widely considered paramount to successful orthodontic therapy.

In an attempt to define general guidelines that would help clinicians decide between camouflage treatment and surgery, Proffit *et al*. reported that extraction camouflage treatment is more likely to be successful from a soft tissue profile perspective if the underlying skeletal discrepancy is not too severe. Specifically, the authors suggest an alternate treatment plan such as orthognathic surgery may be indicated if overjet is greater than 10 mm, mandibular length as measured from gonion to pogonion is greater than 70 mm, the distance from pogonion to nasion perpendicular is greater than 18 mm, and the total face height is greater than 125 mm (W. Proffit, et al. 1992). Other texts report that successful orthodontic camouflage of skeletal malocclusion is likely when the patient has an average or short facial pattern, mild anteroposterior jaw discrepancy, less than 4-6 mm of crowding, normal soft tissue features such as nose, lips and chin, and no transverse skeletal problem (Proffit and Fields 2000). While these studies suggest certain principles that may aid in predicting a successful outcome in terms of profile esthetics when deciding between camouflage treatment and orthognathic surgery, a study examining factors that contribute to either a successful or a compromised occlusal finish in Class II camouflage treatment has not been published. An understanding of factors that promote a successful versus a poor occlusal outcome would serve to guide the clinician in planning and treatment to ensure the best possible final result in cases where camouflage therapy is the best option.

MATERIALS AND METHODS

The study protocol was reviewed and approved by the Institutional Review Board at the University of Iowa under IRB approval ID # 201311751.

Sample Selection

For this study, 65 subjects were evaluated that had previously been treated with 2 premolar extraction camouflage treatment in the Department of Orthodontics at the University of Iowa College of Dentistry. The sample included initial and final study casts of 29 males and 36 females, all of whom were in the permanent dentition at the beginning of treatment and presented with Angle Class II division 1 or 2 malocclusions and no other missing teeth. The subjects were divided into two categories for the purpose of comparison: good finishes and compromised finishes. The good finish group was further subdivided into acceptable and excellent finishes. Assignment to one of these groups was accomplished by evaluating each subject's final models as described below.

Assignment to Finish Categories

As this study is based on a judgment of good versus compromised finishes, we sought first to define these in the most objective way possible. For the purposes of this study, we define a successful finish as one in which the final values for overbite, overjet, and the anterior-posterior (AP) position of the maxillary canines as measured on the subject's final casts are within one standard deviation of the normal mean values measured for untreated Class I subjects in the Iowa Longitudinal Growth Study (ILGS). A compromised finish, therefore, is defined by a final value greater than one standard deviation from the mean for one or more of these variables. Objective evaluation of all 65 final casts in this manner yielded 39 good finishes and 26 compromised finishes.

Further subjective analysis, however, revealed subcategories within the good finish grouping. For example, some casts in the good finish category exhibited excess space distal to the maxillary canines. Others displayed misaligned maxillary second molars, evidence that these teeth were probably not included in the appliance and that anchorage may have been lost during retraction. While these characteristics did not warrant assignment to the compromised finish category, their presence or absence did serve to further segregate the good finish category into merely acceptable finishes and more excellent finishes, respectively. Thus, on a subjective basis, 13 of the original 39 samples in the good category may be viewed as excellent finishes and 26 as acceptable finishes. All subjective decisions were determined by the primary investigator, Tyler Prestwich.

Therefore, for this study a total of 65 samples were allocated objectively into two groups that included 39 good finishes and 26 compromised finishes. Additionally, the good finish category was also divided as above to yield a total of three groups that included 13 excellent finishes, 26 acceptable finishes, and the original 26 compromised finishes. Both the objectively determined two groups and the subjectively determined three groups were used in data analysis. (Figure 1)

ILGS Measurements

Values for overbite and overjet in untreated Class I subjects from the ILGS have previously been analyzed (Johnson et al., 2013 and Roemmich et al., 2013). The values for AP position of the maxillary canines in subjects from the ILGS were measured from the casts of 15 males and 14 females in the permanent dentition. A value of +0.1 mm was recorded when the tip of the maxillary canine was positioned directly in the occlusal embrasure between the mandibular canine and first premolar. If the maxillary canine was positioned more anteriorly then the value retained a positive sign. If the canine was positioned posterior to the embrasure, then a negative value was recorded. (Figure 2) The mean AP position of the right and left maxillary canines in untreated Class I adult dentitions is shown in Table 1.

The AP position of the right and left canines from the experimental casts were measured in the same manner and compared to the mean ILGS values to determine grouping into good or compromised finishes as explained above.

Cast Measurements

All of the following measurements were taken with a Mitutoyo Absolute IP67 digital caliper capable of measuring to the nearest 1/100 of a millimeter (Mitutoyo Corporation, Japan).

To determine the extent of the Class II discrepancy prior to treatment, a linear distance corresponding to the anterior displacement of the mesiobuccal cusp of the maxillary first molar from the buccal groove of the mandibular first molar was measured on both the right and left sides of the initial and final casts. (Figure 3A)

Overbite was measured from the maxillary central incisor exhibiting the greatest vertical overlap with its antagonist. (Figure 3B) Overjet was measured from the facial surface of the most anteriorly positioned maxillary central incisor to the facial surface of its mandibular antagonist. (Figure 3C) For overbite and overjet, the same teeth were measured on both the initial and final casts.

Tooth size was measured for each subject as the mesiodistal width of the teeth at the anatomical contact points. The widths of the incisors, canines, premolars and first molars were measured with the digital calipers and recorded on an Excel spreadsheet (Microsoft, Redmond, Wash). (Figure 4) Tooth size was only measured on the pre-treatment casts as this variable was assumed to have remained the same during the course of treatment.

Arch length was measured in six segments on pre- and post-treatment maxillary and mandibular casts. The segments were defined as anterior (mesial of central incisor to distal of lateral incisor), canine, and posterior (mesial of first premolar to mesial of first molar). (Figure 5A) Post-treatment maxillary arch length in the posterior segments was decreased by the extraction of one premolar. (Figure 5B)

With the acquisition of the above data, tooth-size arch-length analyses were performed for all pre- and post-treatment samples with the aid of an excel spreadsheet. The calculated tooth-size arch-length discrepancies were used as a measure of crowding or spacing in both arches prior to and following treatment. For statistical analysis purposes, a negative sign was given to the calculated value to indicate crowding and a positive value indicates excess spacing.

Utilizing the tooth size data we measured, standard Bolton 6 and Bolton 12 analyses were performed on the initial maxillary and mandibular casts (Bolton 1958). The Bolton ratio was computed for each subject according to the following formulas:

(Sum of mandibular 12/Sum of maxillary 12) × 100 = Overall ratio

(Sum of mandibular 6/Sum of maxillary 6) × 100 = Anterior ratio

Negative values for the Bolton measurements indicate a mandibular excess, while a positive value indicates a maxillary excess.

Measures of Compliance

To assess whether patient compliance plays a role in determining the outcome of Class II camouflage treatment, we conducted a patient database search for all subjects in the study. Axium database searches were carried out to ascertain the total number of appointments, total treatment time, number of failed and cancelled appointments, as well as patient age at the beginning of treatment for all 65 subjects in the study.

Reliability

To determine intra-observer error, seven of the 65 total subjects (three males and four females) were selected at random for repeat evaluation. All measurements were repeated by T.P. on the pre- and post-treatment casts of these seven subjects at least two weeks after the initial measurements were taken. Additionally, all measurements were repeated on these seven subjects by a second examiner, Emily Kopec, to control for inter-observer error. The initial measurements taken by T.P. were used for statistical analysis.

The results of the reliability testing showed a correlation coefficient of 0.99 for both intra- and interobserver measurements, indicating a strong agreement between the two measurements made by T.P. and those made by T.P. and E.K. (Table 2)

Statistical Analysis

Descriptive statistics were conducted. A two-sample t-test was used to detect the significant difference between the two finish groups (good vs. compromised finish) concerning the variables of interest, while a one-way ANOVA with post-hoc Tukey-Kramer test was used to determine whether there were significant differences among three finish groups (excellent vs. acceptable vs. compromised). Additionally, the Shapiro-Wilks test was applied to verify the assumption of normality as the parametric statistical procedures were carried out.

A p-value of less than 0.05 was used as a criterion for statistical significance. Statistical analyses were performed using the statistical package SAS® System version 9.3 (SAS Institute Inc., Cary, NC, USA).

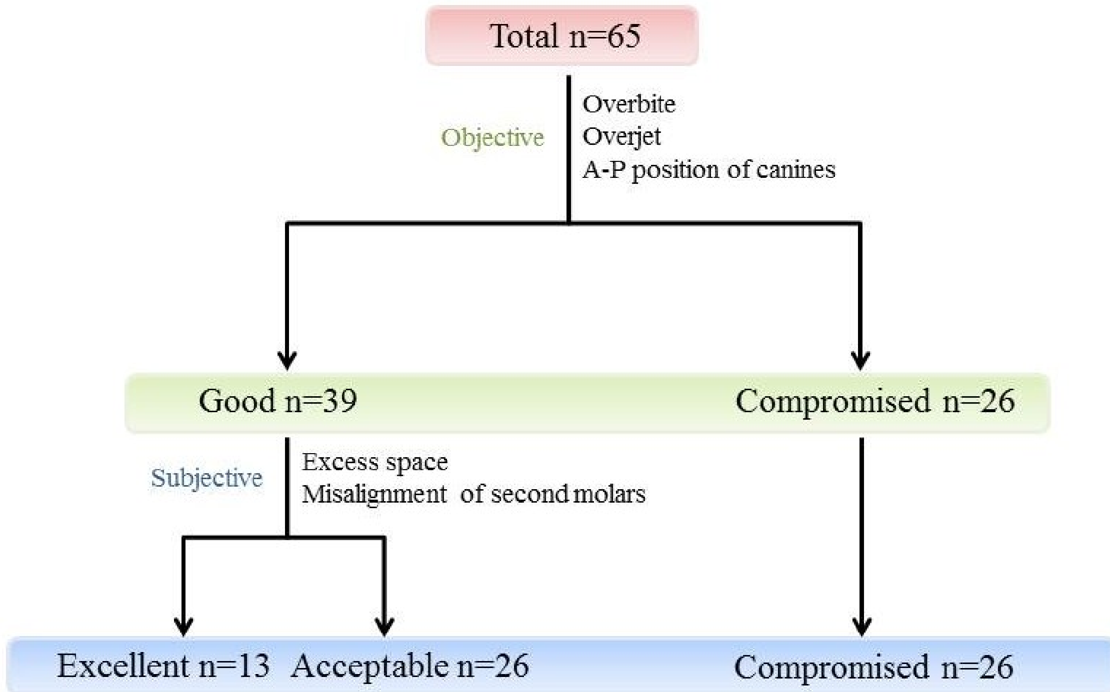

Figure 1. Sample selection and catagorization.

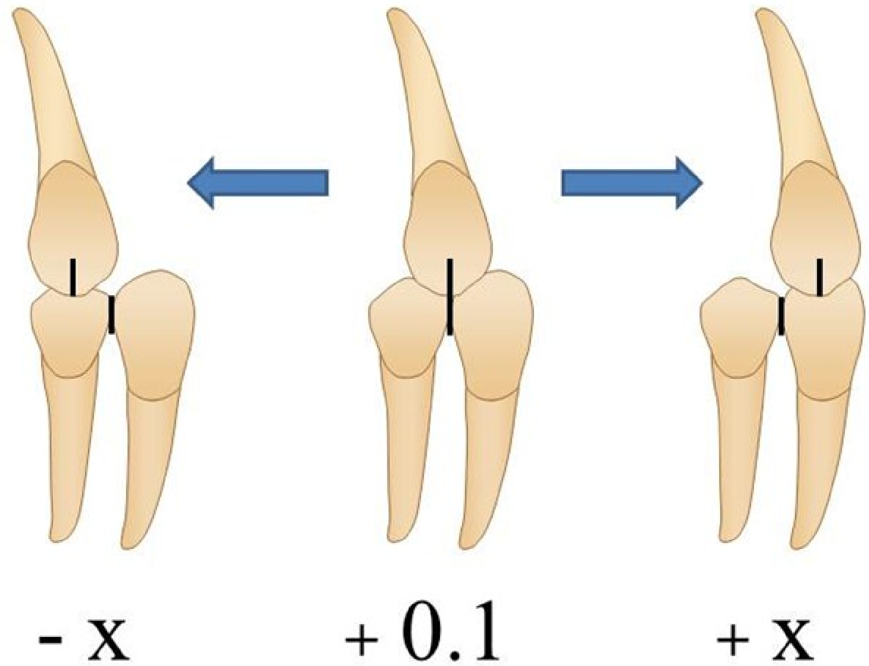

Figure 2. Determining AP position of maxillary canines.

Table 1. Mean AP position of maxillary canines.

	N	Mean	Standard Deviation	Mean + 1 Standard Deviation
Male				
Right	15	0.86	0.77	**1.6**
Left	15	1.22	1.06	**2.3**
Female				
Right	14	1.28	0.77	**2.1**
Left	14	1.19	0.80	**2.0**

Note: Individuals were untreated Class I adult dentitions selected from the Iowa Longitudinal Growth Study.

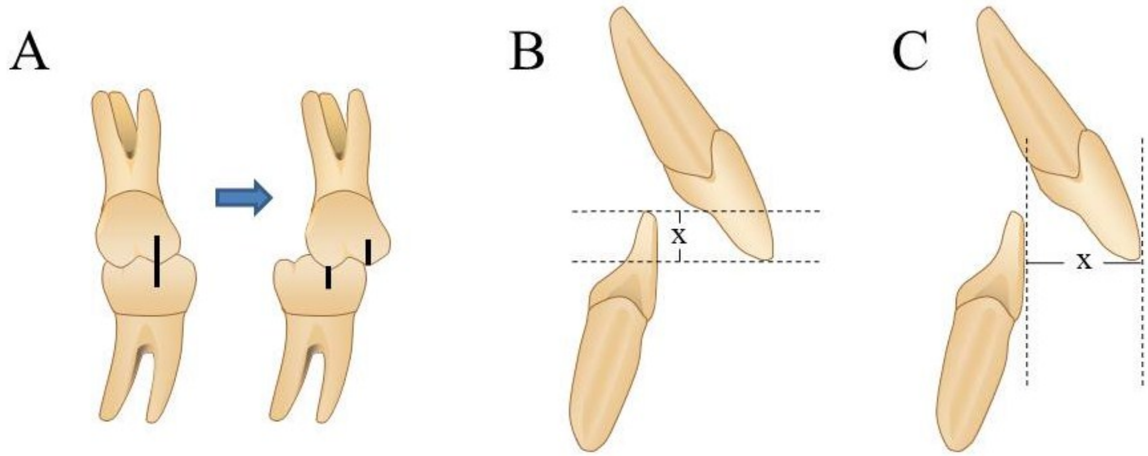

Figure 3. Depictions of molar position, overbite and overjet.

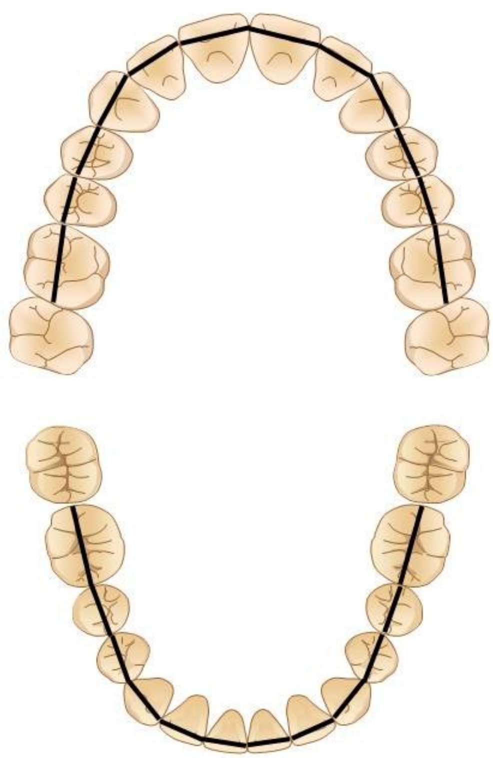

Figure 4. Depiction of tooth size measurements.

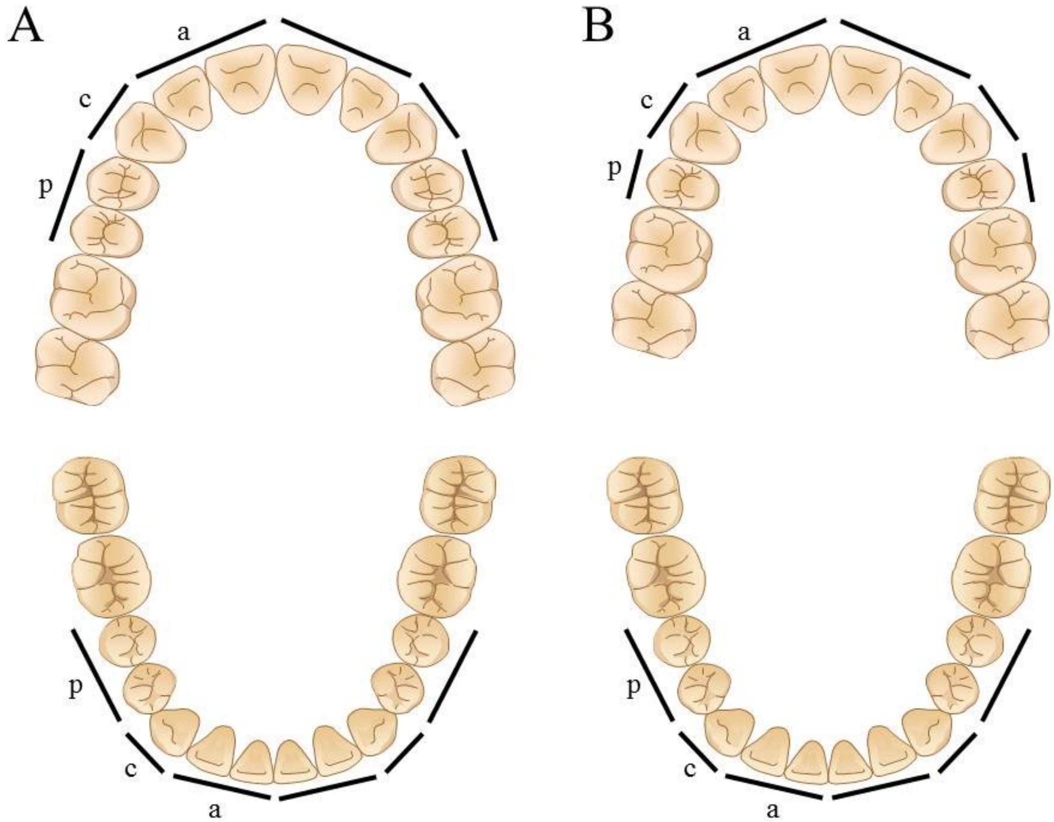

Figure 5. Depiction of arch length measurements.

Table 2. Results of reliability studies.

A. Difference between two measurements made by the primary observer

Variable	N	Mean	Standard Deviation	Minimum	Maximum	Median	P-Value[¥]
For Initial Measurements:							
First Measure	56	42.28	39.34	1.03	105.85	34.43	
Second Measure	56	42.25	39.23	1.66	106.58	32.93	
diff12*	**56**	**0.03**	**1.03**	**-2.53**	**2.18**	**-0.18**	**0.8230**
For Final Measurements:							
First Measure	56	18.49	27.02	-0.90	76.92	3.25	
Second Measure	56	18.41	26.79	0.10	76.41	3.00	
diff12*	**56**	**0.08**	**0.55**	**-1.00**	**2.40**	**0.02**	**0.2922**
For All Measurements:							
First Measure	112	30.38	35.65	-0.90	105.85	5.73	
Second Measure	112	30.33	35.52	0.10	106.58	5.95	
diff12*	**112**	**0.05**	**0.82**	**-2.53**	**2.40**	**0.00**	**0.4864**

B. Difference between two measurements made by the two observers

Variable	N	Mean	Standard Deviation	Minimum	Maximum	Median	P-Value[¥]
For Initial Measurements:							
Observer 1 measures	56	42.26	39.28	1.35	105.75	33.68	
Observer 2 measures	56	42.12	39.23	1.42	105.41	32.33	
diff12**	**56**	**0.15**	**1.45**	**-5.14**	**3.93**	**0.13**	**0.4543**
For Final Measurements:							
Observer 1 measures	56	18.45	26.90	-0.40	76.67	3.09	
Observer 2 measures	56	18.54	27.23	0.07	75.63	3.02	
diff12**	**56**	**-0.09**	**1.40**	**-9.03**	**2.10**	**0.03**	**0.6398**
For All Measurements:							
Observer 1 measures	112	30.36	35.58	-0.40	105.75	5.87	
Observer 2 measures	112	30.33	35.64	0.07	105.41	5.87	
diff12**	**112**	**0.03**	**1.42**	**-9.03**	**3.93**	**0.06**	**0.8292**

Note: Diff12*=Primary Observer's first measurement – Primary Observer's second measurement. Diff12**=Average of Primary Observer's two measurement – Second Observer's measurement.

[¥]Not statistically significant (p>0.05 in all instances) using a paired-sample t-test.

RESULTS

In order to better understand the factors that may play a role in determining the quality of finish in Class II camouflage treatment, we analyzed several variables using each of the subjects' pre- and post-treatment casts and electronic records. The variables selected for study are defined in Table 2.

The variables were measured on both the subjects' initial and final casts, representing the initial and final time points, respectively. Also, the difference in the values between the initial and final time points was calculated for some of the variables as the change that occurred during treatment and was also analyzed. Finally, The Axium patient database at the University of Iowa College of Dentistry was mined for information regarding subject compliance during treatment.

Descriptive statistics for all the variables in the study at different time points are outlined in tables 3-6. Table 3 depicts the mean, standard deviation, minimum, maximum and median for all the variables associated with the compromised finish group (n=26). Table 4 shows the same for the good finish group (n=39), which is a combination of acceptable and excellent finishes. The descriptive statistics for the acceptable (n=26) and excellent (n=13) finishes are illustrated separately in tables 5 and 6, respectively.

Based on the two-sample t-test, the data provide strong evidence to suggest that there is no significant difference in any of the variables measured at the initial time point when comparing the compromised finish group to the good finish group (Table 7). Comparing these two groups at the final time point, however, showed that there are significant differences in overjet, anterior-posterior right and left maxillary canine position, and maxillary arch length at the end of treatment (Table 8). The means for all four of these variables were significantly greater in the compromised finish group than in the good finish group (mean value: 2.31(C) vs 1.67(G) for overjet, 1.59(C) vs. 0.94(G) for right canine position, 1.44(C) vs. 0.91(G) for left canine position, and 62.54(C) vs. 60.76(G) for maxillary arch length). When analyzing the changes in some of the variables over the course of treatment, no significant differences were found between the two groups (Table 9). In addition, there were no differences in the variables used to determine patient compliance (Table 10). These data suggest that while the good finish group has less overjet, canines closer to Class I, and decreased arch length compared to the compromised group at the end of treatment, there are no intrinsic pre-treatment differences between these two groups with regard to the variables studied.

We then sought to determine whether differences might exist if the good finish group was separated into acceptable and excellent finishes, as described in the materials and methods section. Comparing these three groups (compromised, acceptable, and excellent) at the initial time point we found that the mean value for AP position of the right first molar in the excellent finish group was significantly less than that of the acceptable or compromised finish groups, indicating an initial first molar position closer to Class I in the best finishes (mean value: 3.35(E) vs. 4.22(A) vs. 4.54(C)). Besides this factor, however, there were no other differences between the compromised, acceptable, and excellent finish groups at the initial time point (Table 11). Comparing the three groups at the final time point revealed a significantly lower mean value for tooth-size arch-length discrepancy in the maxillary arch of the excellent finish group compared to the acceptable and compromised finish groups (mean value: 0.52(E) vs. 1.70(A) vs. 1.86(C)). A greater positive value for this variable in the acceptable and compromised groups indicates excess spacing compared to the excellent finish group. Similar to the results of the two group comparison, overjet in the acceptable and excellent finish groups was significantly less than the compromised finish group. Also, values for the anterior-posterior position of the right canine were found to be significantly less in the better finish groups, while the position of the left canine was less in the acceptable finish group compared to the other two (Table 12). Comparison of the means of some of the variables over the course of treatment in the three groups showed no significant differences (Table 13). Finally, comparing the compliance factors across the three groups yielded no significant differences (Table 14).

The results of this study suggest that with regard to most of the variables examined, there are no pre-treatment differences between the good and compromised finish groups with the exception of the AP position of the maxillary right first molar. The other differences appear after treatment is completed and include greater values for overjet, anterior-posterior canine position, maxillary arch length, and maxillary tooth-size arch length discrepancy in the compromised finish group. There were no detected differences with regard to changes in the variables over the course of treatment or with regard to patient compliance.

Table 3. Definitions of abbreviations.

Abbreviation	**Definition**
(I, F, or C)mm_ClassII_R	Initial, Final, or Change during treatment in maxillary right first molar position, measured in millimeters.
(I, F, or C)mm_ClassII_L	Initial, Final, or Change during treatment in maxillary left first molar position, measured in millimeters.
(I, F, or C)TSALD_Mx	Initial, Final, or Change during treatment in maxillary tooth-size arch-length discrepancy.
(I, F, or C)TSALD_Mn	Initial, Final, or Change during treatment in mandibular tooth-size arch-length discrepancy.
Ibolton_6	Initial Bolton discrepancy of anterior 6 teeth.
Ibolton_12	Initial Bolton discrepancy of all teeth from the left first molar to the right first molar.
(I, F, or C)mm_OB	Initial, Final, or Change during treatment of overbite, measured in millimeters.
(I, F, or C)mm_OJ	Initial, Final, or Change during treatment of overjet, measured in millimeters.
ITooth_Size_Mx	Initial sum of all tooth widths from first molar to first molar in the maxillary arch, measured in millimeters.
ITooth_Size_Mn	Initial sum of all tooth widths from first molar to first molar in the mandibular arch, measured in millimeters.
(I or F)Arch_Length_Mx	Initial or Final arch length for the maxillary arch, measured in millimeters.
(I or F)Arch_Length_Mn	Initial or Final arch length for the mandibular arch, measured in millimeters.
IMean_Mx_2^{nd}_Bi_Size	Initial mean width of the right and left maxillary 2^{nd} premolars, measured in millimeters.
FCanine_R	Final maxillary right canine position, measured in millimeters.
FCanine_L	Final maxillary left canine position, measured in millimeters.
Total_of_Appts	Total number of appointments during treatment.
Total_Tx_Time	Total treatment time, in months.
Num_of_Failed_Appts	Total number of failed appointments during treatment.
Num_of_Cancelled_Appts	Total number of cancelled appointments during treatment.
Age_at_Start	Age of the patient at the beginning of treatment, in years.

Table 4. Descriptive statistics for compromised finish group.

Compromised Finish Group (C)

Variable	N	Mean	Standard Deviation	Minimum	Maximum	Median
At Initial Time Point:						
Imm_ClassII_R	26	4.54	1.05	2.04	6.10	4.64
Imm_ClassII_L	26	4.46	1.39	2.00	7.70	4.79
ITSALD_Mx	26	-4.84	4.44	-14.96	2.30	-3.91
ITSALD_Mn	26	-2.90	3.88	-12.77	4.54	-2.03
Ibolton_6	26	-0.41	1.35	-2.42	2.60	-0.61
Ibolton_12	26	-0.36	2.56	-4.93	4.86	-0.81
Imm_OB	26	4.81	2.33	0.00	10.09	5.28
Imm_OJ	26	4.88	2.11	1.25	9.41	4.28
ITooth_Size_Mx	26	95.85	5.44	86.53	104.91	95.15
ITooth_Size_Mn	26	87.88	4.81	80.63	99.93	87.33
IArch_Length_Mx	26	70.16	4.70	62.04	81.87	70.41
IArch_Length_Mn	26	63.16	4.54	51.82	78.25	62.74
IMean_Mx_2nd_Bi_Size	26	6.97	0.44	6.25	7.84	6.87
At Final Time Point:						
Fmm_ClassII_R	26	7.06	1.36	3.79	9.58	6.90
Fmm_ClassII_L	26	6.74	1.06	5.15	9.67	6.75
FTSALD_Mx	26	1.86	2.00	-1.21	6.86	1.53
FTSALD_Mn	26	0.08	0.65	-1.21	1.30	0.03
Fmm_OB	26	2.25	0.86	1.00	4.04	2.06
Fmm_OJ	26	2.31	0.91	1.20	4.87	2.06
FCanine_R	26	1.59	1.06	-0.90	3.21	1.71
FCanine_L	26	1.44	0.89	0.10	2.86	1.48
FArch_Length_Mx	26	62.54	3.81	56.15	70.15	61.61
FArch_Length_Mn	26	66.15	3.91	59.89	76.92	65.69
Changes between Two Time Points:						
Cmm_ClassII_R	26	2.52	1.21	-1.13	4.30	2.77
Cmm_ClassII_L	26	2.28	1.78	-1.88	4.97	2.15
CTSALD_Mx	26	6.71	4.41	0.45	17.87	5.33
CTSALD_Mn	26	2.98	3.64	-3.61	12.79	2.32
Cmm_OB	26	-2.57	2.12	-7.05	1.79	-3.02
Cmm_OJ	26	-2.56	2.27	-7.32	2.71	-2.59
Category of Compliance:						
Total_of_Appts	26	26.92	6.69	16.00	41.00	25.00
Total_Tx_Time	26	25.42	8.70	12.00	47.00	23.50
Num_of_Failed_Appts	26	1.35	2.51	0.00	10.00	0.00
Num_of_Cancelled_Appts	26	2.12	2.78	0.00	10.00	1.00
Age_at_Start	26	19.70	9.28	11.72	47.10	15.34

Table 5. Descriptive statistics for good finish group.

Good Finish Group (A + E)

Variable	N	Mean	Standard Deviation	Minimum	Maximum	Median
At Initial Time Point:						
Imm_ClassII_R	39	3.93	1.51	1.03	8.46	3.59
Imm_ClassII_L	39	4.13	1.22	1.14	6.57	4.11
ITSALD_Mx	39	-3.77	4.20	-15.47	5.01	-3.45
ITSALD_Mn	39	-2.11	3.09	-11.01	4.74	-2.22
Ibolton_6	39	-0.44	1.33	-3.41	2.58	-0.70
Ibolton_12	39	-0.48	2.22	-3.96	4.69	-0.77
Imm_OB	39	4.88	1.75	1.47	8.18	5.02
Imm_OJ	39	4.42	1.91	1.00	9.34	4.01
ITooth_Size_Mx	39	94.20	5.35	82.93	108.03	93.53
ITooth_Size_Mn	39	86.29	4.66	77.20	95.43	85.96
IArch_Length_Mx	39	69.61	4.79	60.96	83.31	68.73
IArch_Length_Mn	39	62.99	4.84	55.88	82.44	62.51
IMean_Mx_2nd_Bi_Size	39	6.79	0.48	5.81	7.72	6.75
At Final Time Point:						
Fmm_ClassII_R	39	6.68	0.87	4.74	8.97	6.74
Fmm_ClassII_L	39	6.69	0.97	4.54	9.35	6.70
FTSALD_Mx	39	1.30	1.32	-0.68	5.17	0.90
FTSALD_Mn	39	-0.09	0.76	-1.79	1.15	-0.02
Fmm_OB	39	1.99	0.63	0.92	3.05	2.09
Fmm_OJ	39	1.67	0.52	1.00	2.95	1.59
FCanine_R	39	0.94	0.48	0.10	1.92	0.95
FCanine_L	39	0.91	0.53	0.10	2.20	0.96
FArch_Length_Mx	39	60.76	3.22	53.97	68.36	60.25
FArch_Length_Mn	39	64.57	3.25	58.99	71.66	64.14
Changes between Two Time Points:						
Cmm_ClassII_R	39	2.75	1.59	-1.47	6.12	2.89
Cmm_ClassII_L	39	2.56	1.30	0.30	5.99	2.58
CTSALD_Mx	39	5.07	4.18	-3.90	14.94	5.25
CTSALD_Mn	39	2.02	2.80	-4.49	9.22	1.91
Cmm_OB	39	-2.89	1.89	-6.95	1.11	-2.77
Cmm_OJ	39	-2.75	1.79	-6.61	1.16	-2.57
Category of Compliance:						
Total_of_Appts	39	26.85	8.06	8.00	45.00	26.00
Total_Tx_Time	39	24.56	7.17	8.00	40.00	24.00
Num_of_Failed_Appts	39	0.90	1.79	0.00	8.00	0.00
Num_of_Cancelled_Appts	39	1.85	2.58	0.00	9.00	0.00
Age_at_Start	39	18.12	6.33	11.36	42.59	16.18

Table 6. Descriptive statistics for acceptable finish group.

Acceptable Finish Group (A)

Variable	N	Mean	Standard Deviation	Minimum	Maximum	Median
At Initial Time Point:						
Imm_ClassII_R	26	4.22	1.55	2.10	8.46	3.71
Imm_ClassII_L	26	4.13	1.24	2.01	6.57	4.05
ITSALD_Mx	26	-3.44	4.68	-15.47	5.01	-3.13
ITSALD_Mn	26	-2.13	3.65	-11.01	4.74	-2.20
Ibolton_6	26	-0.46	1.45	-3.41	2.37	-0.68
Ibolton_12	26	-0.85	2.41	-3.96	4.69	-1.63
Imm_OB	26	4.99	1.53	1.48	8.18	5.13
Imm_OJ	26	4.50	1.84	1.00	9.34	4.04
ITooth_Size_Mx	26	93.94	5.29	82.93	108.03	92.62
ITooth_Size_Mn	26	86.31	4.64	77.20	95.43	86.23
IArch_Length_Mx	26	69.66	5.09	61.59	83.31	69.44
IArch_Length_Mn	26	63.11	5.14	57.32	82.44	62.30
IMean_Mx_2nd_Bi_Size	26	6.74	0.45	5.81	7.61	6.71
At Initial Time Point:						
Fmm_ClassII_R	26	6.68	0.99	4.74	8.97	6.71
Fmm_ClassII_L	26	6.64	1.10	4.54	9.35	6.61
FTSALD_Mx	26	1.70	1.38	-0.53	5.17	1.68
FTSALD_Mn	26	-0.08	0.81	-1.79	1.15	-0.15
Fmm_OB	26	2.13	0.56	1.07	3.05	2.17
Fmm_OJ	26	1.78	0.54	1.00	2.95	1.70
Fcanine_R	26	0.88	0.44	0.10	1.54	0.92
FCanine_L	26	0.82	0.51	0.10	1.68	0.89
Farch_Length_Mx	26	61.01	3.12	53.97	68.36	60.83
F_Arch_Length_Mn	26	64.49	3.29	58.99	71.66	64.19
Changes between Two Time Points:						
C_mm_ClassII_R	26	2.46	1.59	-1.47	5.42	2.45
C_mm_ClassII_L	26	2.51	1.25	0.79	5.99	2.58
C_TSALD_Mx	26	5.13	4.75	-3.90	14.94	5.29
C_TSALD_Mn	26	2.04	3.23	-4.49	9.22	2.05
C_mm_OB	26	-2.87	1.73	-6.65	0.36	-2.72
C_mm_OJ	26	-2.72	1.77	-6.61	1.16	-2.54
Category of Compliance:						
Total_of_appts	26	28.15	8.24	8.00	45.00	27.50
Total_Tx_Time	26	24.31	7.83	8.00	40.00	23.50
Num_of_failed_appts	26	0.54	1.17	0.00	5.00	0.00
Num_of_cancelled_appts	26	1.62	2.48	0.00	8.00	0.00
Age_at_start	26	18.86	7.32	11.36	42.59	16.43

Table 7. Descriptive statistics for excellent finish group.

Excellent Finish Group (E)

Variable	N	Mean	Standard Deviation	Minimum	Maximum	Median
At Initial Time Point:						
Imm_ClassII_R	13	3.35	1.29	1.03	5.65	3.56
Imm_ClassII_L	13	4.11	1.25	1.14	6.00	4.11
ITSALD_Mx	13	-4.43	3.10	-8.25	-0.04	-4.15
ITSALD_Mn	13	-2.09	1.58	-4.79	1.57	-2.23
Ibolton_6	13	-0.39	1.09	-1.23	2.58	-0.70
Ibolton_12	13	0.25	1.61	-2.66	2.11	1.01
Imm_OB	13	4.65	2.17	1.47	7.87	4.51
Imm_OJ	13	4.25	2.11	1.18	7.99	3.93
ITooth_Size_Mx	13	94.72	5.66	86.76	105.85	94.11
ITooth_Size_Mn	13	86.27	4.89	79.50	95.35	84.76
IArch_Length_Mx	13	69.52	4.31	60.96	77.05	68.31
IArch_Length_Mn	13	62.77	4.39	55.88	69.74	62.55
IMean_Mx_2nd_Bi_Size	13	6.90	0.55	5.92	7.72	6.83
At Final Time Point:						
Fmm_ClassII_R	13	6.68	0.62	5.50	7.63	6.74
Fmm_ClassII_L	13	6.78	0.67	5.71	8.22	6.70
FTSALD_Mx	13	0.52	0.75	-0.68	1.85	0.45
FTSALD_Mn	13	-0.10	0.68	-1.44	0.82	0.19
Fmm_OB	13	1.71	0.68	0.92	2.92	1.55
Fmm_OJ	13	1.44	0.41	1.00	2.48	1.44
Fcanine_R	13	1.07	0.54	0.10	1.92	1.06
FCanine_L	13	1.10	0.56	0.10	2.20	1.00
Farch_Length_Mx	13	60.25	3.48	56.11	67.33	59.23
F_Arch_Length_Mn	13	64.73	3.32	60.09	71.58	64.14
Changes between Two Time Points:						
C_mm_ClassII_R	13	3.32	1.51	0.53	6.12	3.42
C_mm_ClassII_L	13	2.67	1.45	0.30	5.58	2.75
C_TSALD_Mx	13	4.95	2.88	0.86	8.77	5.25
C_TSALD_Mn	13	1.98	1.74	-1.29	5.09	1.84
C_mm_OB	13	-2.94	2.25	-6.95	1.11	-3.25
C_mm_OJ	13	-2.81	1.92	-6.12	0.26	-2.57
Category of Compliance:						
Total_of_appts	13	24.23	7.29	14.00	37.00	25.00
Total_Tx_Time	13	25.08	5.89	14.00	35.00	24.00
Num_of_failed_appts	13	1.62	2.53	0.00	8.00	0.00
Num_of_cancelled_appts	13	2.31	2.81	0.00	9.00	2.00
Age_at_start	13	16.65	3.44	12.92	23.16	16.18

Table 8. Comparison of two groups at initial time point.

Variables	**Compromised n=26**	**Good n=39**	**p-value**
Initial time point			
Imm_ClassII_R	4.54(1.05)	3.93(1.15)	NS*
Imm_ClassII_L	4.46(1.39)	4.13(1.22)	NS*
ITSALD_Mx	-4.84(4.44)	-3.77(4.20)	NS*
ITSALD_Mn	-2.90(3.88)	-2.11(3.09)	NS*
Ibolton_6	-0.41(1.35)	-0.44(1.33)	NS*
Ibolton_12	-0.36(2.56)	-0.48(2.22)	NS*
Imm_OB	4.81(2.33)	4.88(1.75)	NS*
Imm_OJ	4.88(2.11)	4.42(1.91)	NS*
ITooth_Size_Mx	95.85(5.44)	94.20(5.35)	NS*
ITooth_Size_Mn	87.88(4.81)	86.29(4.66)	NS*
IArch_Length_Mx	70.16(4.70)	69.61(4.79)	NS*
IArch_Length_Mn	63.16(4.54)	62.99(4.84)	NS*
IMean_Mx_2^{nd}_Bi_Size	6.97(0.44)	6.79(0.48)	NS*

Note: Variables defined in table 3. All measurements are in millimeters and presented as mean(+/- standard deviation).

*Not significant ($p>0.05$) using the two-sample t-test.

Table 9. Comparison of two groups at final time point.

Variables	Compromised n=26	Good n=39	p-value
Final Time Point			
Fmm_ClassII_R	7.06(1.36)	6.68(0.87)	NS*
Fmm_ClassII_L	6.74(1.06)	6.69(0.97)	NS*
FTSALD_Mx	1.86(2.00)	1.30(1.32)	NS*
FTSALD_Mn	0.08(0.65)	-0.09(0.76)	NS*
Fmm_OB	2.25(0.86)	1.99(0.63)	NS*
Fmm_OJ	2.31(0.91)	1.67(0.52)	**0.0023**
FCanine_R	1.59(1.06)	0.94(0.48)	**0.0063**
FCanine_L	1.44(0.89)	0.91(0.53)	**0.0100**
FArch_Length_Mx	62.54(3.81)	60.76(3.22)	**0.0457**
FArch_Length_Mn	66.15(3.91)	64.57(3.25)	NS*

Note: Variables defined in table 3. All measurements are in millimeters and presented as mean(+/- standard deviation).

*Not significant (p>0.05) using the two-sample t-test.

Table 10. Comparison of changes over treatment of two groups.

Variables	Compromised n=26	Good n=39	p-value
Changes During Treatment			
Cmm_ClassII_R	2.52(1.21)	2.75(1.59)	NS*
Cmm_ClassII_L	2.28(1.78)	2.56(1.30)	NS*
CTSALD_Mx	6.71(4.41)	5.07(4.18)	NS*
CTSALD_Mn	2.98(3.64)	2.02(2.80)	NS*
Cmm_OB	-2.57(2.12)	-2.89(1.89)	NS*
Cmm_OJ	-2.56(2.27)	-2.75(1.79)	NS*

Note: Variables defined in table 3. All measurements are in millimeters and presented as mean(+/- standard deviation).

*Not significant (p>0.05) using the two-sample t-test.

Table 11. Comparison of compliance of two groups.

Variables	Compromised n=26	Good n=39	p-value
Compliance			
Total_of_Appts	26.92(6.69)	26.85(8.06)	NS*
Total_Tx_Time	25.42(8.70)	24.56(7.17)	NS*
Num_of_Failed_Appts	1.35(2.51)	0.90(1.79)	NS*
Num_of_Cancelled_Appts	2.12(2.78)	1.85(2.58)	NS*
Age_at_Start	19.70(9.28)	18.12(6.33)	NS*

Note: Variables defined in table 3. All measurements are in millimeters and presented as mean(+/- standard deviation).

*Not significant (p>0.05) using the two-sample t-test or the nonparametric Wilcoxon rank-sum test.

Table 12. Comparison of three groups at initial time point.

Variables	Compromised n=26	Acceptable n=26	Excellent n=13	p-value
Initial time point				
Imm_ClassII_R	4.54(1.05)	4.22(1.55)	3.35(1.29)	**0.0352**
Imm_ClassII_L	4.46(1.39)	4.13(1.24)	4.11(1.25)	NS*
ITSALD_Mx	-4.84(4.44)	-3.44(4.68)	-4.43(3.10)	NS*
ITSALD_Mn	-2.90(3.88)	-2.13(3.65)	-2.09(1.58)	NS*
Ibolton_6	-0.41(1.35)	-0.46(1.45)	-0.39(1.09)	NS*
Ibolton_12	-0.36(2.56)	-0.85(2.41)	0.25(1.61)	NS*
Imm_OB	4.81(2.33)	4.99(1.53)	4.65(2.17)	NS*
Imm_OJ	4.88(2.11)	4.50(1.84)	4.25(2.11)	NS*
ITooth_Size_Mx	95.85(5.44)	93.94(5.29)	94.72(5.66)	NS*
ITooth_Size_Mn	87.88(4.81)	86.31(4.64)	86.27(4.89)	NS*
IArch_Length_Mx	70.16(4.70)	69.66(5.09)	69.52(4.31)	NS*
IArch_Length_Mn	63.16(4.54)	63.11(5.14)	62.77(4.39)	NS*
IMean_Mx_2nd_Bi_Size	6.97(0.44)	6.74(0.45)	6.90(0.55)	NS*

Note: Variables defined in table 3. All measurements are in millimeters and presented as mean(+/- standard deviation).

*Not significant (p>0.05) using the post-hoc Tukey-Kramer test.

Table 13. Comparison of three groups at final time point.

Variables	Compromised n=26	Acceptable n=26	Excellent n=13	p-value
Final Time Point				
Fmm_ClassII_R	7.06(1.36)	6.68(0.99)	6.68(0.62)	NS*
Fmm_ClassII_L	6.74(1.06)	6.64(1.10)	6.78(0.67)	NS*
FTSALD_Mx	1.86(2.00)	1.70(1.38)	0.52(0.75)	**0.0394**
FTSALD_Mn	0.08(0.65)	-0.08(0.81)	-0.10(0.68)	NS*
Fmm_OB	2.25(0.86)	2.13(0.56)	1.71(0.68)	NS*
Fmm_OJ	2.31(0.91)	1.78(0.54)	1.44(0.41)	**0.0010**
FCanine_R	1.59(1.06)	0.88(0.44)	1.07(0.54)	**0.0048**
FCanine_L	1.44(0.89)	0.82(0.51)	1.10(0.56)	**0.0084**
FArch_Length_Mx	62.54(3.81)	61.01(3.12)	60.25(3.48)	NS*
FArch_Length_Mn	66.15(3.91)	64.49(3.29)	64.73(3.32)	NS*

Note: Variables defined in table 3. All measurements are in millimeters and presented as mean(+/- standard deviation).

*Not significant (p>0.05) using the post-hoc Tukey-Kramer test.

Table 14. Comparison of changes over treatment of three groups.

Variables	Compromised n=26	Acceptable n=26	Excellent n=13	p-value
Changes During Treatment				
Cmm_ClassII_R	2.52(1.21)	2.46(1.59)	3.32(1.51)	NS*
Cmm_ClassII_L	2.28(1.78)	2.51(1.25)	2.67(1.45)	NS*
CTSALD_Mx	6.71(4.41)	5.13(4.75)	4.95(2.88)	NS*
CTSALD_Mn	2.98(3.64)	2.04(3.23)	1.98(1.74)	NS*
Cmm_OB	-2.57(2.12)	-2.87(1.73)	-2.94(2.25)	NS*
Cmm_OJ	-2.56(2.27)	-2.72(1.77)	-2.81(1.92)	NS*

Note: Variables defined in table 3. All measurements are in millimeters and presented as mean(+/- standard deviation).

*Not significant (p>0.05) using the post-hoc Tukey-Kramer test.

Table 15. Comparison of compliance of three groups.

Variables	Compromised n=26	Acceptable n=26	Excellent n=13	p-value
Compliance				
Total_of_Appts	26.92(6.69)	28.15(8.24)	24.23(7.29)	NS*
Total_Tx_Time	25.42(8.70)	24.31(7.83)	25.08(5.89)	NS*
Num_of_Failed_Appts	1.35(2.51)	0.54(1.17)	1.62(2.53)	NS**
Num_of_Cancelled_Appts	2.12(2.78)	1.62(2.48)	2.31(2.81)	NS**
Age_at_Start	19.70(9.28)	18.86(7.32)	16.65(3.44)	NS**

Note: Variables defined in table 3. All measurements are in millimeters and presented as mean(+/- standard deviation).

*Not significant (p>0.05) using the post-hoc Tukey-Kramer test.

**Not significant (p>0.05) using the non-parametric Kruskal-Wallis test.

DISCUSSION

The treatment of Class II malocclusion in non-growing patients is a frequently encountered challenge in orthodontics. One common method of treatment for such individuals involves the extraction of two maxillary premolars and subsequent masking of the skeletal discrepancy by retraction of the anterior teeth. This treatment modality presents challenges, which if not understood or accounted for can lead to a less-than-ideal end result. Many could benefit from a greater understanding of the various factors that play a role in determining the quality of finish for these cases.

Our results show that mean values for overjet and the AP position of the right and left maxillary canines are significantly greater in the compromised finish group compared to the good finish group at the end of treatment, representing more overjet and mesially displaced canines in compromised finishes. This relationship was maintained when the good finish group was separated into acceptable and excellent finish groups. These results were expected as they were some of the variables we used to categorize each subject into a particular finish group. Thus, if we categorized a particular subject as having an overjet greater than one standard deviation from the mean compared to a normal control, then we would expect this to be reflected in the final analysis.

We also found that maxillary arch length and tooth-size arch-length discrepancy were significantly greater in the compromised finish group compared to the good and excellent finish groups, respectively, at the end of treatment. These results suggest a greater amount of spacing in the maxillary arch in the compromised group. When the Bolton discrepancies were compared between groups, no significant difference was detected, suggesting a mechanical basis for this finding.

A difference in pre-treatment AP position of the maxillary right first molar was detected, which was the only difference observed at that time point. Our data suggest that a mean mesial displacement of the first molar 3.35mm or less prior to treatment is associated with an excellent finish, while a greater Class II position of 4.54 mm or more is associated with a compromised finish. (Table 11) This result could indicate that the greater the Class II discrepancy at the start of treatment, the more difficult it may be to achieve an excellent result using standard mechanics. Interestingly, we did not find a significant difference in the AP position of the first molar at the end of treatment and while the change in position of the first molar was numerically greater in the excellent finish group, this difference was not statistically significant.

With the exception of the position of the first molar mentioned above, none of the other 13 variables measured on the pre-treatment casts were different between groups. This indicates that factors such as initial overbite, overjet, maxillary or mandibular crowding, Bolton discrepancies and tooth size do not play a role in determining the outcome of Class II camouflage treatment. These negative results seem to support the notion that a good or excellent finish is determined more by the mechanics utilized during treatment, than by any pre-existing anatomical factors.

Of particular interest was that the variables we measured to assess patient compliance during treatment were not different between groups. One might speculate that a patient exhibiting a compromised finish may have had more failed or cancelled appointments, leading the clinician to terminate treatment before ideal results were obtained. This was not the case, however. These findings also support the notion that treatment mechanics play a predominant role in determining the quality of the finish. The variables for patient compliance we measured in this study were selected for ease of collection from an electronic database. Any effort to develop this aspect of the project further could involve examining the details of the patient's records to assess compliance with oral hygiene or appliances such as headgear, etc.

Limitations of the Study

This study was limited in scope due to the number of subjects we were able to procure from the College of Dentistry that fit all the inclusion criteria. Due to the need for a larger sample size, all Class II subjects meeting the inclusion criteria were included in the study, including both division 1 and division 2 malocclusions. It is conceivable that this study may have produced different results if division 1 and division 2 malocclusions were analyzed separately. Also, except for the patient database search for compliance variables, this study only examined factors that were measurable on patients' initial and final casts. This required the assumption that all the casts were trimmed appropriately in centric occlusion. Additionally, we did not examine all of the variables that may possibly play a role in determining treatment outcome. Other variables not measured in this study may be important in achieving a clinically excellent result. For example, the mesial rotation of the maxillary first molar was not evaluated in this study but might be involved in decreasing the arch length or excess spacing seen in some of the acceptable and compromised finishes.

Clinical Application

The results of this study seem to indicate that treatment mechanics, rather than pre-existing anatomical factors contribute most to the quality of the finish in Class II camouflage treatment. One exception may be the AP position of the maxillary first molar. This finding seems to suggest that the more Class II an individual is, the more difficult it will be to achieve an excellent finish. In other words, a clinician may need to pay more attention to mechanics and anchorage factors during treatment with these patients to make sure all of the extraction space can be closed when a Class I canine is attained.

Future Directions

This study serves as a pilot for further investigation into this patient population. Future directions of this project include analyzing more variables and comparing them between the two and three groups outlined here. One such variable could be molar rotation, as mentioned above. Also, the widths of individual teeth, such as the canines and incisors, could be compared between groups to help describe the differences we have observed in tooth-size arch-length discrepancy. In addition, cephalometric variables such as SNA, SNB, ANB, FMA, SN-U1, and inter-incisal angulation could be compared between groups to determine whether skeletal or other dental factors are involved in the outcome of this type of treatment. Another direction may be to increase the numbers of patients in the study. If enough patients can be acquired, a population study may be undertaken to fully analyze and define aspects of the Class II camouflage patient. Finally, while we have concluded that treatment mechanics may play a predominant role in determining the quality of the finish in these cases, it would be interesting to investigate as far as possible the individual mechanics that were used in each case. If this information was available, the variables could include such things as TADs or headgear for anchorage. Comparing the groups of this study with the type of mechanic used, as well as patient compliance when appropriate, may shed more light on what can be a challenging problem for many clinicians.

SUMMARY AND CONCLUSIONS

Class II malocclusion in non-growing individuals is treated in one of two ways – masking or surgery. If the dental and skeletal discrepancy is great enough, masking usually involves extraction of two maxillary premolars and subsequent incisor retraction and closure of overjet. This is the option of choice for patients without profile concerns, or who have medical or financial concerns. However, this treatment modality can sometimes result in less-than-ideal results.

In the present study, we sought to understand what factors may influence the outcomes of this type of treatment. 65 subjects meeting the inclusion criteria were included in this study. The total sample was divided into good and compromised finish categories based on the criteria explained in the materials and methods section. The good finish group was further subdivided into two groups, acceptable and excellent finishes. Several variables were measured on each subject's initial and final casts and compared between groups to determine whether any were associated with a particular finish group.

At the initial time point, a mesial displacement of the maxillary right first molar by 3.35mm or less was found to correspond significantly to an excellent finish. This may indicate that if an individual presents with molars that are Class II by 3 mm or less, then the prognosis is better than if that same individual had a greater Class II discrepancy. This notion is in harmony with other published studies (W. Proffit et al., 1992). None of the other variables for the initial time point were found to be significantly different, suggesting that treatment mechanics, rather than a pre-existing occlusal factor, plays a predominant role in treatment outcome.

This hypothesis is further supported by our findings that none of the variables measuring patient compliance were found to be different between the good and compromised groups.

Finally, mean values for overjet and the AP position of the maxillary right and left canines were found to be greater in the compromised group at the end of treatment, which was expected as these were some of the criteria with which we originally categorized the groupings. Also, we found that the maxillary arch length and tooth-size arch-length discrepancy were greater in the compromised group, indicative of excess spacing in this group at the end of treatment. Based on the other findings of this study, we contribute this result to differences in the mechanics used by individual practitioners.

In the future, studies examining the particular mechanics used, and compliance where applicable, in this population will yield valuable insights into this area of patient research.

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