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Surgical Versus Orthodontic Correction for Class II Patients: Age and Severity in Treatment Planning and Treatment Outcome

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Abstract

Treatment options for Class II malocclusion include orthognathic surgery. Treatment choices are particularly difficult for young patients because of the uncertainty regarding future growth. Surgical treatment has generally been considered necessary for older patients with more severe Class II problems. The treatment records of more than 500 patients with Class II malocclusion were reviewed. Patients were grouped according to their initial treatment plan (surgery or orthodontics) and treatment outcome (overjet [OJ] reduced to <4 mm or not). Discriminant function analyses using data from the patient's pretreatment cephalogram were used to determine whether age, in combination with malocclusion severity, could predict the choice of treatment, and whether a simple set of pretreatment variables could predict the success or failure of OJ reduction. The derived equations were tested in a similar group of growing Class II children. Although the data showed clinicians use patient's age in determining treatment choice, age did not seem to be associated with treatment outcome. The majority of the variability that determined the success or failure of OJ reduction was not explained by patient's age or malocclusion severity. These findings suggest other factors, including psychosocial variables, need to be explored if we are to gain a better understanding of why treatments succeed or fail.

Moderate to severe Class II malocclusion becomes apparent as the permanent incisors erupt. This can motivate patients (and their parents) to seek advice about the type and timing of treatment. Class II treatment alternatives have been related broadly to the age of the patient and severity of the condition. Preadolescents with moderate to severe jaw discrepancy are frequently seen as candidates for growth modification with appliances designed to induce differential growth between the maxilla and mandible. For adolescents or young adult patients with little realistic possibility of significant future differential growth, treatment is more likely to be either repositioning the teeth to camouflage the skeletal discrepancy or, for the more severe and/or older patient, surgical correction. Even though the goals of these alternative treatment approaches may be the same, namely improved esthetics and a stable functional pattern with long-term dental health, the timing of treatment, mechanics used, and direction of tooth movement are substantially different.

Treatment choices for preadolescents and teenagers are particularly difficult because of the uncertainty regarding the magnitude and direction of remaining growth. The concept of an envelope of discrepancy¹ delineating the limits of orthodontic treatment and, by inference, suggesting criteria for surgical management is an intuitively appealing and widely accepted idea. Unfortunately, studies that provide useful clinical guidelines or set thresholds to aid in treatment decisions are infrequent. Recent prospective trials of early growth modification for

Class II patients emphasize the variability in treatment response and the real possibility that little, or even occasionally unfavorable, skeletal changes might result.²⁻⁷

In an early study reporting the outcome of treatment for 264 consecutively treated patients, 111 of whom were classified as Class II, Division 1, Berg⁸ highlighted the fact that not all orthodontic treatment is equally successful. In his sample, close to 50% of the patients were judged to have less than satisfactory treatment outcomes, with an approximately 30% probability of failure to eliminate an increased overjet (OJ). Berg⁸ characterized these failure patients as initially having had one or more of the following: large OJ (> 10 mm), ANB angle of 7° or greater, mandibular plane angle of 40° or greater, posterior rotation of the mandible, or inadequate tongue-lip balance. A somewhat greater failure rate was noted by Nashed and Reynolds⁹ when examining postorthodontic relapse in 50 consecutively finished patients who had initially had severe Class II malocclusion (OJ, 10 to 15 mm). In their conclusions, they stated “no firm pretreatment predictors of success or failure for overjet reduction were found.” In a similar retrospective review of the effectiveness of Class II treatment, O’Brien et al,¹⁰ using the peer assessment rating (PAR) index (a summary occlusal index) as a measure of treatment outcome, related pretreatment severity to both the magnitude of the treatment gain and treatment outcome.

An earlier study at this institution, using the records of 40 age- and gender-matched pairs of Class II children treated either surgically or with orthodontics alone, suggested two discriminant variable models that might be used to predict treatment success.¹¹ These models included the following measures: OJ, ANB angle, mandibular body length, and facial height. Because the pairs of children in this sample were matched on age and gender to control for differences in size, the influence of age and gender could not be evaluated in the regression analysis. A follow-up study by Proffit et al¹² using a larger sample with a more restricted age range largely confirmed the importance of these parameters in Class II treatment decisions. Since then, studies by Cassidy et al,¹³ Bollen and Hujuel,¹⁴ and Gramling¹⁵ have proposed different combinations of anteroposterior and vertical discrepancy that, together with age, might be used to predict treatment outcome and hence guide clinical decisions.

A somewhat different approach to defining the choice between surgery and orthodontics was taken by Cassidy et al.¹³ A discriminant function analysis was used to select from a large pool of patient records those patients who, on the basis of their discriminant function scores alone, might have been deemed eligible for either orthodontic treatment or surgery. Even in this largely adult, nongrowing sample, age appeared to be by far the most important variable in determining which treatment a patient actually received. There was no mention of whether the surgical patients had previously had orthodontic treatment that failed to correct the problem, necessitating later surgery, or whether the orthodontic patients had been presented a surgical plan they had rejected.

From these studies, it seems safe to conclude the criteria clinicians use when deciding whether preadolescent and adolescent patients with a Class II malocclusion should be treated surgically are not well delineated. How these criteria affect the treatment outcome is also poorly understood. Few studies relate or test treatment-planning decisions in a formal way to the subsequent treatment outcomes. The purposes of the present study were: (1) to assess whether clinicians do use the patient’s age in combination with malocclusion severity to choose alternative treatments, (2) to explore whether a simple set of pretreatment characteristics can be identified that, in conjunction with the patient’s age, could be used to predict the success or failure of Class II correction, and (3) to test the ability of the derived models to correctly classify a similar group of Class II growing patients.

Method

The sample was selected from the sequential list of patients treated at the University of North Carolina (UNC) since 1972 (the year the Dento-facial Program database of orthognathic surgical patients was implemented) to identify a broad spectrum of Class II severity across a wide age range. The records of Caucasian patients were included if, at the initial records, the patient had an OJ of 6 mm or greater, was aged younger than 21 years at the final (end-of-treatment) cephalogram, and there was a clear unambiguous record of the initial treatment plan. Records of patients with congenital defects, obvious facial asymmetry, missing radiographs, or history of prior orthodontic or surgical treatment were excluded. The percentage of orthodontic and surgical patients who met the selection criteria is given for each year of treatment start in Figure 1.

The patients were categorized according to treatment plan: those initially planned for orthodontic treatment, and those initially proposed and accepting a combined surgical-orthodontic plan. Patients offered a choice of orthodontic or combined surgical treatment who elected orthodontics were placed in the orthodontic group. Patients initially planned for orthodontic treatment but later changed to surgery were placed in the orthodontic-failure group. The treatment outcome was classified as a success if the final OJ on the deband cephalogram was less than 4 mm and there was a positive incisor overbite, or failure if the final OJ was 4 mm or greater and/or the patient had a overbite of 0 mm or less. The treatment outcome assessment was independent of the treatment plan categorization. Thus, four subgroups were created: orthodontic success, orthodontic failure, surgical success, and surgical failure. Examples of cephalometric tracings of representative patients from each group are shown in Figure 2.

All cephalograms were taken in natural head position, with the patient seated and their teeth in occlusion (leaf gauges were not used). Each radiograph was traced and digitized by one of two research technicians using the UNC 139-point digitizing model adapted from Walker and Kowalski.¹⁶ Measurements were made using an x-y coordinate system established with sella nasion line rotated 6° anteriorly as the horizontal reference and the vertical reference perpendicular through sella. The method error for landmark registration ranged from 0.24 mm (sella) to 1.2 mm (pogonion). The reliability of landmark location and digitizing, indicated by the intraclass correlation statistic, ranged from 0.89 for overbite to 1.00 for anterior face height. A restricted set of 15 measures was used to describe the position and relationship of the maxillary and mandibular skeletal and dental units (Table 1). The cephalometric measures for the four treatment/outcome groups were compared using a one-way analysis of variance to determine if there were significant mean differences among the groups. Linear contrasts were performed to compare the success and failure subgroups within each treatment type. An additional comparison was made between the orthodontic-failure and surgical-success groups. The patients in the surgical-failure group were not used in any further analysis because it was believed these patients might represent a rather extreme subset of Class II patients or those who had experienced some unusual event.

The three patient groups, orthodontic success, orthodontic failure, and surgical success, were stratified by gender. Within gender, each group was randomly divided into two subsets of patients using a 3:1 ratio and were labeled the Development and Test samples. Six cephalometric measures (OJ, overbite, ANB angle, mandibular body length, mandibular plane angle, and A-N perpendicular) were chosen to reflect a patient's skeletal and dental proportions and, except for mandibular body length, were largely independent of the patient's size (and therefore age). Using the development sample, data from these six measures were entered, together with age, gender, and year of treatment start, into a stepwise discriminant analysis to identify the set of variables that best separated patients

planned for orthodontics from those planned for surgical treatment. The success of the derived equation in predicting how clinicians choose between orthodontic treatment and orthognathic surgery for growing Class II patients was then explored using data from the smaller subset of patients (the Test sample). A second stepwise discriminant analysis was performed, this time using only the orthodontic patients in the development sample to see if a simple set of variables could be used to predict the success or failure of treatment. Once again, the derived function was evaluated using data from the subset of orthodontic patients in the test sample. Significance for entry and removal of a variable from the explanatory set of nine measures was set at 0.15. This moderate level of significance was used because the intent of the analysis was to provide the best discrimination using the sample estimates.

Results

Four hundred sixty-nine orthodontic patients (52% girls) and 101 surgical patients (70% girls) met the selection criteria. Ninety-eight orthodontic (21%) and 26 surgical patients (26%) failed to achieve the goal of a final OJ less than 4 mm with a positive overbite (Table 1). In Figure 3, the distribution of initial age and initial OJ is given for boys and girls in the orthodontic and surgery treatment groups and is approximately equal for both genders. In Figure 4, the distribution of initial age and initial OJ is given according to the success or failure of OJ reduction for both treatment methods. Again the distribution is presented as the percentage of patients in each group. In Figure 5, the magnitude of the final OJ is given for the failure patients only. Forty-nine of the orthodontic failures (50%) and 21 of the surgical failures (80%) had a final OJ between 4 and 5 mm. Patients with a final OJ less than 4 mm who also had an open bite at the end of treatment are included in this figure.

The pretreatment mean, SD, and *P* values for contrasts between groups for the 15 selected cephalometric measures are listed in Table 1. Measures of anteroposterior and vertical skeletal discrepancy, together with maxillary and mandibular position, confirm surgical plans were used for patients with more severe anteroposterior and vertical Class II problems. The differences in linear measures between orthodontic and surgical patients, such as mandibular body length and ramus height, probably reflect that the surgical patients were, on average, more than 3 years older than the orthodontic patients at the start of treatment.

The cephalometric data comparing the success and failure of OJ reduction in the two treatment groups suggest a gradient of severity from orthodontic success through surgical failure for a number of measures (Table 1). This trend is apparent for anteroposterior and vertical skeletal jaw relationship, maxillary protrusion, mandibular position, and incisor OJ. There are few statistically significant differences between the cases classified as success and failure in each treatment group. When these occur, they are primarily in horizontal measures for the orthodontic-treatment group and vertical measures for the surgical-treatment group. It should be noted the number of patients in the failure groups are quite small, and the variation in most measures is large. Again, the differences between linear measures for the orthodontic-failure and surgical-success groups should be interpreted with caution because the surgical patients were older and therefore bigger at their initial records.

Seven of the nine variables entered in the stepwise discriminant analysis to predict the clinician's choice of treatment met the entry and removal criteria (Table 2). The variables were added in the following sequence: age at the beginning of treatment, ANB angle, A-N perpendicular, overbite, year of start, mandibular plane angle, and mandibular body length. Whereas age made the largest contribution to explaining the variability in the clinician's choice of treatment, the total average squared canonical correlation of the equation was still only 0.39. When developing an equation that would distinguish success and failure orthodontic cases, only four variables, A-N perpendicular, OJ, gender, and ANB angle, met

the entry and removal criteria. In this case, the total average squared canonical correlation was only 0.07, leaving the majority of the variation in treatment outcome unexplained by the variables considered. In Table 3, the correct classification rates for both development and test samples obtained using these derived functions are given for both the clinician's choice of treatment and for the prediction of success of orthodontic treatment. As expected, given the canonical correlations in Table 2, the correct classification rates were considerably greater for the choice of treatment discrimination than for the prediction of orthodontic success or failure. Also as expected, the correct classification rates decreased for both the development and test samples as the number of variables in each prediction model decreased, but this decrease was small.

In Table 4, descriptive statistics are listed for selected cephalometric measures for those cases correctly and incorrectly classified in the full models. As expected from the average squared canonical correlations, incorrect classification to treatment method occurred primarily on the basis of age, and there was little to distinguish the classification patterns of orthodontic patients in terms of the predicted success or failure of OJ reduction.

Discussion

The primary aim of this study is to determine the extent to which age influences both clinicians' choice of treatment and treatment outcome for growing patients with Class II malocclusion. The retrospective nature of this study, however, introduces some biases that are difficult to interpret. For example, it is impossible to know whether the patients who had surgery as an initial plan might have been successfully corrected with orthodontic treatment. Similarly, the treatment outcome for the patients with missing radiographs is unknown, and no comparison is available to show how the patients with missing data differed from those included on this study. This missing information may contain some important clinical trends but is unfortunately not available. In addition, the results of this retrospectively collected sample must reflect the philosophy and treatment decisions of the clinicians involved, and as such may not be applicable to other clinical settings.

Despite the long history of surgical correction of patients with skeletal problems, this data set contains surprisingly few Class II adolescents treated surgically at this institution during the last 25 years. The rather restrictive inclusion criteria used in this study, together with the number of patients for whom part of the records were missing, may in part account for so few patients being available. However, it is apparent that orthodontic correction was and still remains by far the most prevalent form of Class II correction for this age group. The sample identified had a wide distribution of both age (7 to 19 years) and OJ (6 to 17 mm). Whereas the genders were represented equally in the orthodontic group, the surgical group was predominantly females and, on average, approximately 3 years older. The considerable overlap in age and malocclusion severity between the surgical and orthodontic patients parallels the findings of Cassidy et al,¹³ who suggested the criteria for treatment decisions, particularly for surgical patients, are not well delineated. This study also parallels their finding that age appears to be the single most important variable in determining the clinician's choice of treatment. However, it is also apparent that even for older adolescent patients with severe Class II malocclusion, there is some possibility of successful orthodontic treatment. Age and malocclusion severity, to a certain extent, predict the clinician's choice of treatment, but they do not predict the success or failure of OJ reduction.

In identifying the sample, OJ was used not only as the measure of Class II severity, but also as a measure of treatment success. Recognizing that OJ is a dental measure, increased OJ is both a quick and simple screening measure and has been shown to be a good proxy measure for skeletal severity.¹⁷ Increased OJ is also the primary reason Class II patients seek

treatment.^{18,19} Failure to reduce an OJ to the ideal of 2 to 4 mm may therefore be construed as a failure to correct a patient's presenting problem, which gives some validity to the use of OJ as a measure of treatment success. When looking at the distribution of success and failure in the orthodontic and surgical groups (Fig 4), there is a disappointing number of failures (20% and 25%) with each treatment approach. However, this failure rate is in line with that of other studies using OJ as the marker for successful treatment. In Figure 5, it should be noted that 49% of the orthodontic and 50% of the surgical failures had a final OJ between 4 and 5 mm. Whether such a small increase beyond the ideal should be considered a failure in treatment is debatable. Reliable and valid measures of the patient's perception of their teeth and face and of their and their parents' satisfaction with treatment are both urgently needed to help clinicians evaluate the effectiveness of different treatment approaches. Orthodontics has been slow in developing useful patient-centered outcomes.

The idea of an envelope of discrepancy that limits the magnitude of a correction is complicated in growing patients by consideration of the patient's age. Presumably, this stems from the fact that younger patients are more likely candidates for growth modification. It may be of interest that in a recent prospective trial of early Class II treatment at the same institution, no useful correlations between the magnitude of skeletal change during early growth modification and a patient's skeletal or dental maturity, chronological age, or various markers for malocclusion severity could be determined.¹⁹ Admittedly, the range for age and maturity in this trial were quite constrained, which could result in a null association. In this present sample, it seems clear clinicians consider age when determining which treatment a patient will receive. Age, at least as reflected by the canonical correlations in Table 3, appears to make the largest contribution to the clinician's choice of treatment. Whether age should do so is less clear, particularly because age did not appear as a significant variable in the discriminant analysis used to develop a model to predict the success of treatment. Admittedly, the ability in this data set to predict treatment outcome was very low. None the less, it is clear from this and other data sets that a wide range of skeletal and/or dental severity can be treated orthodontically, and this orthodontic treatment can be successful throughout adolescence.

Conclusion

In conclusion, reliance on the presenting anatomic arrangement of teeth and jaws, even when coupled with the patient's age, clearly ignores many of the factors that determine the treatment response. Age, skeletal severity, and gender (which may be a proxy measure for skeletal maturity or even for patient compliance), used separately or together, provide no more useful predictors of treatment success than the toss of a coin. This is not to gainsay the usefulness of cephalometric analysis in the diagnosis of a patient's problems or as an aid to planning treatment. It simply reflects that there must be many additional factors, over and beyond simple presenting morphological characteristics, that contribute to the successful outcome of orthodontic treatment. Further understanding of the biological and psychosocial factors that determine a child's treatment response, together with improved methods of monitoring such variables as skeletal and dental response, patient's compliance, or cooperation with treatment would help determine what we may expect from young patients with complex problems who present early for evaluation and treatment recommendations. It would be misleading to suggest older adolescents will always require surgical correction or treating a patient at an early age will necessarily favor orthodontic correction.

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Figure 1.
Percentage of patients meeting the selection criteria shown according to the years treatment was started.

Figure 2.

Initial and end-of-treatment cephalometric tracings of representative patients for each of the four groups (orthodontic success, orthodontic failure, surgical success, surgical failure). The pretreatment morphology is shown by a solid line and the treatment outcome is shown by a broken line.

Orthodontic Patients (Female [■] n = 244, Male [▨] n = 225)

Surgery Patients (Female [■] n = 71, Male [▨] n = 30)

Figure 3.
Distribution of age and initial overjet for males and females receiving orthodontic or surgical treatment.

Orthodontic Patients (Success [■] n = 371, Failure [▨] n = 98)

Surgery Patients (Success [■] n = 75, Failure [▨] n = 26)

Figure 4.
Distribution of age and initial overjet for the success and failure patients treated orthodontically or surgically.

Figure 5.

Distribution of final overjet (OJ) for patients classified as failure of treatment, either orthodontic or surgical, given as the percentage of the patients in either group. Patients for whom the overjet was less than 4 mm but who had an overbite of 0 mm or less are included.

Table 1

Descriptive Statistics, Mean, and Standard Deviation for Initial Cephalometric Values

	Ortho Success, n = 371 (45%)*	P [†]	Ortho Failure, n = 98 (60%)*	P [‡]	Surgery Success, n = 75 (32%)*	P [§]	Surgery Failure, n = 26 (23%)*
Age	11.5 (2.1)	.55	11.9 (2.1)	.00	14.8 (2.0)	.90	15.4 (1.7)
Skeletal relation							
ANB	5.4 (2.0)	.15	5.8 (2.1)	.008	6.2 (2.8)	.22	7.2 (2.7)
A-B diff	9.6 (3.2)	.002	10.9 (3.2)	.00	13.8 (4.9)	.07	15.1 (4.2)
Max skeletal							
SNA	82.7 (3.7)	.02	81.6 (4.0)	.18	80.9 (3.9)	.70	80.5 (3.2)
Mx unit length	89.9 (4.9)	.86	89.5 (5.1)	.001	92.6 (6.1)	.04	90.3 (6.1)
A-NP	-1.4 (3.7)	.02	-2.5 (4.1)	.11	-3.4 (4.1)	.71	-3.7 (3.5)
Md skeletal							
SNB	77.2 (3.3)	.000	75.8 (3.4)	.002	74.2 (3.7)	.30	73.4 (2.9)
Md unit length	70.7 (5.5)	.99	70.7 (4.6)	.004	73.1 (5.9)	.43	72.1 (5.4)
Pg-NP	-11.3 (7.1)	.002	-13.9 (6.7)	.002	-16.3 (9.2)	.16	-19.6 (6.5)
Vertical relation							
Md pl angle	31.9 (5.9)	.16	33.0 (6.0)	.06	34.9 (9.0)	.01	38.6 (6.2)
AFH:PFH	1.55 (0.1)	.66	1.58 (0.1)	.20	1.61 (0.2)	.41	1.68 (0.14)
LFH:TFH	0.57 (0.0)	.60	0.57 (0.0)	.26	0.58 (0.0)	.12	0.59 (0.02)
Ramus hgt	55.5 (5.9)	.23	54.7 (5.9)	.001	57.6 (5.9)	.07	55.2 (6.3)
Dental relation							
Overjet	7.8 (1.9)	.001	8.6 (2.3)	.28	8.6 (2.8)	.004	10.4 (3.0)
Overbite	4.8 (2.4)	.39	5.1 (2.5)	.001	3.6 (4.2)	.33	3.0 (4.0)

NOTE. Values given for four groups with comparisons between the success and failure of each treatment method and between the orthodontic failure and surgical success group. *P* for contrasts are reported if the overall model for the one-way analysis of variance was <.05. Values expressed as mean (SD).

* Percentage male.

[†] *P* for contrasts between orthodontic-success and orthodontic-failure groups.

[‡] *P* for contrasts between orthodontic-failure and surgical-success groups.

[§] *P* for contrasts between surgical-success and surgical-failure groups.

Table 2

Variables Identified as Significant in Clinicians' Choice of Treatment and Prediction of Success and Failure of Orthodontic Treatment

	<i>P</i> for Entry	Average Squared Canonical Correlation
Clinician's choice of treatment		
Age at start of Tx	.0001	0.26
ANB angle	.0001	0.29
A-N perpendicular	.0001	0.34
Overbite	.0006	0.36
Mandibular plane angle	.0032	0.37
Year of start	.0095	0.38
Mandibular body length	.0428	0.39
Success of orthodontic treatment		
A-N perpendicular	.005	0.02
Ovmjet	.007	0.04
Sex	.013	0.06
ANB angle	.051	0.07

NOTE. Variables are listed in the order in which they were entered into the discriminant analyses. *P* for inclusion in the model was .15.

Table 3

Percentage of Patients Correctly Classified by Different Models for Clinician's Choice of Treatment and Patients With Correctly Predicted Orthodontic Treatment Outcome

	Developmental Sample		Test Sample	
	Choose Orthodontics (%)	Choose Surgery (%)	Choose Orthodontics (%)	Choose Surgery (%)
Clinician's choice of treatment				
7 variable	89	86	85	53
4 variable model	87	88	87	47
2 variable model	83	84	87	47
1 variable model	83	84	83	47
	Predict Success (%)	Predict Failure (%)	Predict Success (%)	Predict Failure (%)
Success of orthodontic treatment				
4 variable model	63	69	59	63
2 variable model	58	59	60	50
1 variable model	56	57	57	46

NOTE. Both developmental and test sample groups were used.

Table 4

Descriptive Statistics of Cephalometric Variables Mean and Standard Deviation

	Orthodontic Treatment		Surgical Treatment	
	Correct Classification (n = 307)	Classified as Surgery (n = 47)	Correct Classification (n = 50)	Classified as Orthodontics (n = 7)
Clinician's choice of treatment				
Beginning age	11.4 (1.7)	15.2 (2.0)	15.6 (2.1)	13.5 (1.1)
ANB angle	5.4 (1.9)	5.4 (2.5)	6.7 (2.8)	5.1 (1.4)
A-N perpendicular	-1.2 (3.7)	-4.1 (4.6)	-3.9 (4.4)	-4.2 (3.9)
Overbite	4.9 (2.2)	4.0 (3.3)	2.7 (4.2)	6.8 (1.9)
Mand plane angle	31.8 (5.7)	35.4 (7.2)	36.4 (9.1)	28.7 (5.9)
Mand body length	70.6 (4.8)	71.8 (6.0)	73.5 (6.1)	72.9 (6.0)
	Success		Failure	
	Correct Classification (n = 175)	Classified Failure (n = 104)	Correct Classification (n = 53)	Classified as Success (n = 23)
Success of orthodontic treatment				
A-N perpendicular	0.0 (3.5)	-3.5 (3.4)	-3.9 (4.3)	-0.3 (3.5)
Ovmjet	7.2 (1.5)	8.7 (1.9)	8.7 (2.2)	7.4 (1.4)
ANB angle	5.1 (2.1)	5.8 (1.8)	5.8 (2.1)	5.3 (1.5)

NOTE. Cephalometric variables are for the cases correctly and incorrectly classified in the full variable models, for both the clinician's choice of treatment (orthodontics v surgery) and the prediction of the successful overjet reduction. Values expressed as mean (SD).