Cephalometric predictor variables for treatment of Class II Division 2 malocclusions

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To many orthodontists, it is clinically relevant to avoid extractions in the treatment of Angle's Class II Division 2 (Class II/2) malocclusions. The most commonly cited side effects from extraction treatment are a tendency toward flattening of the facial profile and deepening of the bite. The aim of this study was to select a model of cephalometric predictor variables for treatment decision-making for Class II/2 malocclusions with premolar extraction versus non-extraction. The pretreatment lateral cephalograms and study models of 92 patients (46 boys and 46 girls) with a Class II/2 malocclusion were analyzed. Discriminant analysis was applied to select pretreatment predictive variables for the treatment options. Stepwise variable selection of the cephalometric and model measurements at the first observation identified 5 predictive variables ($p < 0.001$). In order of significance, they are ANB, overjet (OJ), S to Go (S-Go), lower (L) arch-length discrepancy, and lower lip to the E-plane (L lip-E plane). The discriminant function generated was Dz = -0.5652(ANB) + 0.6271(OJ) + 0.4126(S-Go) + 0.6183 (L arch-length discrepancy) -0.3496(L lip-E plane). Using this discriminant function, a standardized score (Dz) > 0 can roughly be translated into non-extraction treatment. For a score < 0, extraction treatment can be assigned. The cutoff score for this function was Dz = 0. The group membership correctly classified was 83.7%. The majority of the misclassified patients were grouped around zero. This study showed that the discriminant function was dependent upon ANB, OJ, S to Go, lower arch-length discrepancy, and the lower lip to the E-plane in order to make an extraction decision for Class II/2 malocclusions. *(J Dent Sci, 1(1):16-22, 2006)*

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It is recognized that the Angle Class II Division 2 malocclusion (Class II/2) exhibits a deep overbite with lingually inclined maxillary upper central incisors[1]. The incidence of class II/2 malocclusions is relatively rare in the population, at 0.5%~5%[2,3].

The etiology is generally believed to be genetic[4]. However, studies have shown that heredity is not the sole controlling factor[5]. Skeletally, Class II/2 malocclusions generally have an orthognathic maxilla, relatively short and retrognathic mandible, relatively prominent chin, a hypodivergent facial pattern, retroclined upper central incisors, and a deep overbite[6]. A study by Walkow and Peck[7] showed a relatively normal dental arch form with compatible transverse dimensions in both arches of Class II/2 groups, except in the mandibular intercanine width dimension. Dentally, systemically reduced incisor tooth-size may serve as a trait associated with Class II/2 malocclusions[4]. There are also two soft-tissue and musculature abnormalities cited, i.e., sublabial contraction (deep sublabial furrow) and upper lip proversion[8]. One cephalometric comparison between Class II/1 and Class II/2 malocclusions among Chinese subjects showed that both divisions had a nearly identical degree of Class II skeletal relationships even though the Class II/2 group had less prognathic maxillae and mandibles[9]. In another cephalometric evaluation, Cleall and Begole[10] stated

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that on average, Class II/2 patients have essentially normal skeletal patterns outside the immediate dental area.

There are several possible treatment options commonly employed in the orthodontic correction of Class II/2 malocclusions, e.g., headgear, functional appliance, and fixed appliance[8,10,11]. Fixed appliance therapy presents several treatment options, one of which is premolar extraction. If maximum anterior retraction is the objective, most orthodontists would extract the four first premolars[12]. When less anterior retraction is desired, other extraction combinations have been proposed. In general, orthodontists tend to extract teeth more frequently in patients with crowding and protrusion and less frequently in those with little or no crowding and acceptable profiles.

The primary benefits of extraction, especially the four first bicuspids, are said to be a reduction in incisor protrusion and increased stability[13-15]. The advantages of a non-extraction approach are said to be improved temporo-mandibular joint (TMJ) health[16-18], broader, more pleasing smiles[19], and preservation of the tooth mass[1]. The most common side effects cited with extraction treatment for Class II/2 cases are a tendency toward flattening of the facial profile and deepening of the bite[20]. However, the decision to treat one way or the other should not be based on empirical data, clinical experience, or medico-legal implications, but on objective, unbiased data.

Determining the optimal treatment effects from extraction and non-extraction therapy is compromised by a susceptibility bias because patients treated one way tend to differ at the outset from those treated another way[21,22]. And most patients are susceptible to only one treatment option. For example, there are some patients whose teeth are severely crowded and protrusive that can only be treated by extraction. Moreover, the problem is not easily (or ethically) tested by random treatment assignment[23]. Consequently, any predictive variables for premolar extraction and non-extraction treatments will be meaningful for Class II/2 patients that are candidates for both treatments and who can be treated by either method.

Therefore, the purpose of this study was to select a model of cephalometric and model variables for treatment decision-making for Class II/2 malocclusions by premolar extraction versus non-extraction.

MATERIALS AND METHODS

The parent sample consisted of 2 groups of patients formerly treated at St. Louis University, St. Louis, MO. The non-extraction group (n=46) included 20 males and 26 females, with a mean age of 13.78 years. The extraction group (n=46) which were all treated by extraction of four first premolars, included 20 males and 26 females, with a mean age of 13.84 years. Each of the 92 patients was chosen according to the following criteria: 1) Caucasian, 2) a pre-treatment Angle Class II /2 malocclusion of at least a "half-step", 3) orthodontic treatment with an edgewise appliance, 4) documentation with pre- and post-treatment lateral cephalograms and dental models, and 5) all cases having achieved an Angle Class I relationship after orthodontic treatment.

1. Cephalometric analysis

A transparent digitizer (Scriptel RDT-1212, Scriptel Corp., Columbus, OH) and a commercial digitization program (Dentofacial Planner, version 4.22A, Dentofacial Software, Toronto, Canada) were used to generate the individual measurements from the cephalograms (through the use of 71 digitized points) for the St. Louis University analysis (Table 1). To improve the analysis reliability, the landmarks were traced on a 0.003-in frosted-acetate overlay prior to digitization.

2. Model study

Photocopies (1:1) of the occlusal surface of each pretreatment model for the subsamples were digitized (Table 2). The various measurements of arch length (in 2 segments, 6-1-6), arch width (at canines, second premolars, and first molars), available space (in 4 segments, 6-3-1-3-6), arch depth, and lower anterior irregularities used in the discriminant analysis were recorded.

3. Statistical analysis

A stepwise discriminant analysis was performed (subprogram DISCRIMNANT, SPSS-X, release 3.1, SPSS, Chicago, IL) on the parent sample using the 53 independent variables (age, gender, and the cephalometric and model measurements) as predictor variables. The resulting discriminant function was then used to assign standardized discriminant scores to each of the 92 subjects. Descriptive statistics (means and standard deviations) were calculated for all data.

Table 1. Cephalometric variables (DOP, Downs occlusal plane; FOP, functional occlusal plane.)

Measurement	Characteristic
Angular measures	
ANB	Maxillo-Mandibular relationship
FMIA	Lower incisor protrusion
IMPA	Lower incisor protrusion
Interincisal angle	Incisor protrusion
1 to NB	Lower incisor protrusion
Lower Z angle	Profile convexity
Mandibular Plane angle	Face height/shape
SNA	Maxillary size/position
SNB	Mandibular size/position
SN-Downs occlusal plane	Occlusal plane cant/position
SN-functional OP	Occlusal plane cant/position
SN-Palatal Plane	Palatal cant/position
1 to SN	Upper incisor protrusion
1 to NA	Upper incisor protrusion
Upper Z angle	Profile convexity
Y-Axis	Mandibular size/position
Linear measures	
ANS-Menton	Lower face height
Articulare-Gnathion	Mandibular size
1 to A-Pogonion	Lower incisor position
1 to NB	Lower incisor position
Lower lip to E-plane	Profile convexity
Molar classification (DOP)	Maxillo-mandibular dental relation
Molar classification (FOP)	Maxillo-mandibular dental relation
N-ANS	Upper face height
N-Menton	Total face height
Overbite (DOP)	Vertical incisor overlap
Overbite (FOP)	Vertical incisor overlap
Overbite (DOP)	A-P incisor relationship
Overbite (FOP)	A-P incisor relationship
PNS-A point	Maxillary size
Pogonion-NB	Mandibular position
Sella-Articulare	Mandibular position
Sella-Gonion	Mandibular size
1-NA	Upper incisor position
1-NA	Upper incisor position
6-PTV	Upper molar position
Wits (DOP)	Maxillo-mandibular relationship
Wits (FOP)	Maxillo-mandibular relationship
Ratios	
Lower face height/Total face height	Vertical proportion
Upper face height/Total face height	Vertical proportion

(DOP: Downs occlusal plane; FOP: functional occlusal plane.)

Table 2. Model variables

Measurement	Characteristic
Lower arch length	Antero-posterior arch dimension
Upper arch length	Antero-posterior arch dimension
Lower 3-3 width	Dental arch width
Lower 6-6 width	Dental arch width
Upper 6-6 width	Dental arch width
Upper 3-3 width	Dental arch width
Lower arch-length discrepancy	Overall crowding
Upper arch-length discrepancy	Overall crowding
Irregularity index	Incisor crowding

RESULTS

In standardized form, the discriminant function was Dz = -0.57(ANB) + 0.63(OJ) + 0.41(S-Go) + 0.62 (L arch-length discrepancy) -0.35 (L lip to E-plane) (Table 3). After the standardized discriminant scores were ranked in order, 25 subjects that fell within about one standard deviation of zero in each group were chosen. The 50 “borderline” patients were assumed to be similar with respect to their dentofacial characteristics and free from a susceptibility bias that was significant to the original extraction decision (Figure 1). The treatment group membership correctly classified 83.7% of patients (Table 4). The majority of the misclassified patients were grouped around zero.

DISCUSSION

Orthodontists have long been confronted with a fundamental dilemma: to extract or not to extract? The choice of treatment presumably should be based on the anticipated benefits. However, nearly all arguments are to some extent based on diagnostic information of questionable reliability and validity. Accordingly, the purpose of this study was to select a cephalometric model and model variables to predict treatment decision-making for Class II/2 malocclusions by extraction versus non-extraction of the four first premolars.

To identify this model of cephalometric and model variables for treatment prediction, a discriminant analysis was performed on the parent sample (N=92). The discriminant function derived from this study incorporated 5 predictor variables. In order of significance, they are ANB, OJ (DOP), S to Go, lower arch-length discrepancy, and lower lip to the E-plane. These variables represent the criteria commonly used by clinicians to determine the treatment choice. Because a Class II patient with a greater ANB angle, more protrusive lower lip, smaller posterior facial height (a high angle tendency), and a greater overjet would have a more-convex profile. And previous studies showed that the inter-canine width and arch length decrease

Table 3. Summary of the stepwise discriminant analysis of the parent sample

Step	Variable name	Wilks’Lambda	Standardized coefficient
1	ANB	0.84719*	-0.56523
2	OJ (DOP)	0.64152*	0.62710
3	S to Go	0.59764*	0.41258
4	Lower arch-length discrepancy	0.56338*	0.61892
5	Lower lip to E-plane	0.55261*	-0.34960

* p <0.0001 (N=92)

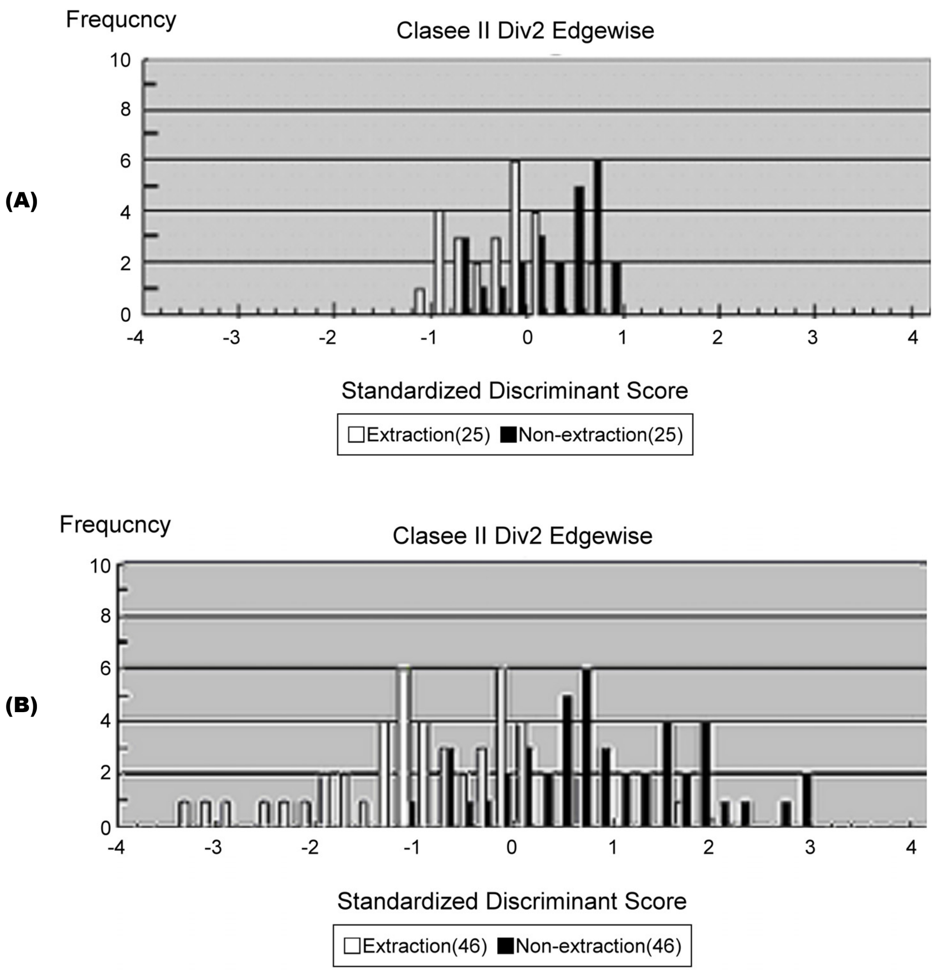

Figure 1. *Standardized discriminant scores. A: parent samples; B: borderline samples.*

with increasing age[24-26], therefore, a Class II/2 patient with a greater ANB angle, more protrusive lower lip, larger lower arch-length discrepancy, smaller posterior facial height, and a greater overjet would tend to be treated by extraction. This is also true for either an Angle Class II, Division 1 or an Angle Class I malocclusion patient.

The result of discriminant analysis, i.e., the discriminant function (Dz), was -0.57(ANB) + 0.63 (OJ) + 0.41(S-Go) + 0.62(L arch-length discrepancy)

Table 4. **Classification results for the discriminant function (N = 92)**

	Predicted Group Membership	
Actual Group Membership	Extraction	Non-extraction
Extraction (N=46)	39 (84.8%)	7 (15.2%)
Non-extraction (N=46)	8 (17.4)	38 (82.6%)

Parent cases correctly classified: 83.7%

-0.35 (L lip to E-plane). Accordingly, negative discriminant scores in this study generally represented extraction subjects, whereas positive scores represented non-extraction subjects. The 25 extraction and 25 non-extraction patients whose Dz scores were closest to zero were chosen as "borderline" samples for further analyses of treatment effects.

Investigation showed that, from 10 to 12 years of age there was a decrease in the inter-canine width and that it continued to decrease during adulthood[24]. Moreover, the arch length decreases with increasing age during adolescence and early adulthood as reported by Brown and Daugaard-Jensen[25]. Moorrees and associates[26] stated that decreases in arch length begin at age 3, with the decrease being greater in the mandible. Hence, orthodontists are generally not in favor of lower arch expansion to relieve crowding. Although the extraction decision is multifactorial, it is apparent that a lower arch-length discrepancy (crowding) plays an important role as shown by the Dz.

Theoretically, the correction of a Class II malocclusion can be achieved by restriction or redirection of maxillary growth, mandibular growth enhancement, or maxillary and mandibular tooth movement. The Class II mechanics may exhibit some orthopedic effects, although the distal displacement was not statistically significant after an extended treatment time[27,28]. Another study also showed that the proclination of the upper incisors and deep bite correction did not result in mandibular anterior positioning, nor was there evidence that the mandible was posteriorly displaced in ClassII/2 malocclusions[29]. These findings serve to emphasize the importance of growth in the correction of Class II malocclusions[30-32]. Accordingly, accounting for the growth effects on treatment or relapse, the EGU (expected growth unit) may provide a useful estimate of the amount of growth during treatment or retention[33] and should also be taken into consideration in the decision-making process.

With regard to overjet correction, the major correction for the non-extraction subsample comes from protraction of both the upper and lower incisors. As with molar correction, differential jaw growth (i.e., ABCH) plays an important role in overjet correction, especially for the extraction subgroup[34]. In any event, the two different overjet correction methods both seem to have essentially marked impacts on the soft tissue profile.

Rains and Nanda[35] showed that the lower lip was more variable than the upper lip in response to differences in upper incisor movement. Other studies[36-39] described various tooth-to-lip-movement ratios. In our previous study[40], the profile measurement for the non-extraction subgroup showed no significant change, although the profile measurement appears fuller when compared with the extraction subsample profile. In contrast, the profile in the extraction subsample at the end showed considerable lower lip retraction and a more recessive profile. The study[40] reflected the effect of changes in the position of the upper incisors on the lower lip (1:5). This may be more significant for Class II Division 2 malocclusions than for other types of malocclusion, a change that may or may not be desirable for a given individual and should be taken into consideration, especially for "borderline" patients.

CONCLUSIONS

This study presents a comparative investigation of various orthodontic treatments, i.e., extraction vs. non-extraction therapies. This study showed that the discriminant function was dependent upon ANB, OJ, S to Go, lower arch-length discrepancy, and lower lip to the E-plane to make the extraction decision for Class II/2 malocclusions.

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