A comparative study of cephalometric and arch width characteristics of Class II division 1 and division 2 malocclusions

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SUMMARY The aim of this compound cephalometric and arch-width study was to determine any dental and/or skeletal differences between subjects with Class II division 1 and Class II division 2 malocclusions. The dento-skeletal characteristics of Class II subjects were evaluated using lateral cephalometric radiographs and dental casts of 90 untreated patients. The sample included 46 Class II division 1 patients (19 girls and 27 boys) with a mean age of 15.27 ± 2.48 years, and 44 Class II division 2 patients (27 girls and 17 boys) with a mean age of 15.95 ± 3.25 years. The intermolar, interpremolar and intercanine measurements were carried out on study models. The radiographs were digitized and processed using Dolphin Imaging software. In addition to standard descriptive statistical calculations, an independent samples *t*-test was carried out in order to compare the two groups. The non-parametric Mann–Whitney *U* test was utilized for the parameters for the data which were not normally distributed.

The only statistically significant difference between the groups for the study model measurements was mandibular intercanine width. The cephalometric results revealed that SNB angle was responsible for the skeletal sagittal difference between the two groups. In addition, the Class II division 1 group had higher vertical proportions and the Class II division 2 group a more concave profile with a prominent chin. The sagittal skeletal pattern of Class II division 2 subjects was found to be very similar to the Class I skeletal relationship, with no evidence of any mandibular restriction.

Introduction

It is essential to know the descriptive characteristics of different types of malocclusions and their dental and skeletal structures in order to produce an appropriate treatment plan with suitable treatment mechanics and retention regime.

As one of the most frequently encountered orthodontic problems, Class II malocclusions have been analysed in many cephalometric and dental model studies. Moorrees *et al*. (1969) used dental study casts to compare arch dimensions of untreated Class II division 1 and division 2 groups and concluded that in Class II division 2 subjects the maxillary and mandibular intercanine distances were greater than the control-reference population, whereas intermolar distances were normal. On the other hand, in the Class II division 1 group the intercanine and intermolar distances were found to be smaller than average. Unlike Moorrees *et al*. (1969), Buschang *et al*. (1994) and Walkow and Peck (2002) indicated in their studies that division 2 subjects showed a reduced intercanine width. In another dental cast study, Canut and Arias (1999) assessed the pre- and post-treatment and post-retention study models of 30 Class II division 2 subjects in order to evaluate the long-term changes in arch dimensions. They concluded that the mandibular arch width usually showed a decrease after retention and this was associated with post-retention mandibular irregularity and crowding.

A study comparing various study casts and cephalometric measurements of adults with normal occlusions and adults with Class II division 1 malocclusions revealed that the Class II division 1 group had a tendency to a posterior crossbite (Staley *et al*., 1985). In a more recent investigation, the craniofacial morphology in Class II division 1 children with and without a deep bite was evaluated, and the results showed that an anterior mandibular growth rotation occurred especially in subjects with a lack of incisor support (Karlsen, 1994). When Class II division 2 malocclusions were considered, some studies have found no maxillomandibular dentoalveolar discrepancy (Demisch *et al*., 1992; Peck *et al*., 1998). However, Pancherz *et al*. (1997) stated that mandibular retrusion was a common characteristic not only of Class II division 1 subjects but also of division 2 subjects.

Examination of these investigations revealed that no definite dental and skeletal differences appear to exist between Class II division 1 and division 2 malocclusions (Pancherz *et al*., 1997; Zentner *et al*., 2003; Riesmeijer *et al*., 2004). The absence of any clear-cut differences may be due to several factors such as insufficient sample size, lack of homogeneity in the age groups and variation in dento-skeletal selection criteria.

The aim of this study was to determine which dental and skeletal factors are different between Class II division 1 and division 2 subjects.

Subjects and methods

The data consisted of the lateral cephalometric radiographs and dental casts of 90 untreated Class II subjects collected from patient records at the Orthodontic Clinic, Yeditepe University. The subjects' ages and genders are summarized in Table 1. The criteria for inclusion were:

1. No history of previous orthodontic treatment.
2. Presence of the permanent dentition (including second permanent molars).
3. Bilateral half unit Class II or greater canine and molar relationships for both groups.
4. Proclination of the maxillary anterior teeth with an overjet of more than 7 mm without an open bite for Class II division 1 subjects.
5. Retroclination of the maxillary anterior teeth (at least of the two central incisors) and a deep bite (complete vertical coverage by a maxillary central incisor of the crown of the corresponding mandibular incisor) for Class II division 2 cases.

Data collection

Dental cast measurements: A universal digital calliper was used to measure the transverse widths of the upper and lower dental casts to the nearest 0.01 mm. The distance between the mesiobuccal cusp tips of the molars, buccal cusp tips of the first and second premolars and cusp tips of the canines were measured in order to determine the intermolar, interpremolar and intercanine measurements (Figure 1).

Cephalometric measurements: The radiographs were scanned into a digital format at 300 dpi, and displayed on a high resolution monitor. All the scanned bitmap images of the radiographs were then digitized and processed by one investigator (FI) using Dolphin Imaging Software 9.0 (Los Angeles, California, USA). The measurements were obtained for 16 skeletal, four dental and six soft tissue parameters. The related landmarks are shown in Figure 2.

Statistical method

Statistical calculations were performed with GraphPad Prisma Version 3.0 software (San Diego, California, USA).

Table 1 Age range in years and gender distribution of the experimental groups.

	n	Mean	SD	Minimum	Maximum
Class II division 1					
Females	19	15.50	± 2.08	13.00	19.50
Males	27	15.22	± 2.12	13.50	21.00
Total	46	15.27	± 2.48	13.00	21.00
Class II division 2					
Females	27	16.05	± 1.69	13.50	20.00
Males	17	15.78	± 2.38	13.50	22.00
Total	44	15.95	± 3.25	13.50	22.00
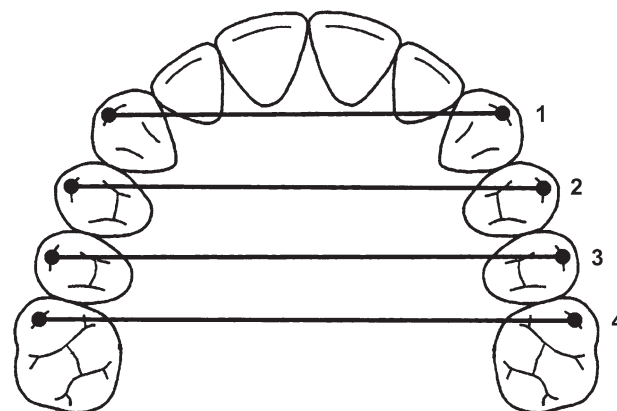
Figure 1 Measurements carried out on the dental casts. 1 Intercanine distance, 2 Interfirst premolar distance, 3 Intersecond premolar distance, 4 Intermolar distance.

In addition to standard descriptive statistics (mean and standard deviation), an independent samples *t*-test was carried out in order to allow comparison of the malocclusions as well as gender groups (Tables 2 and 3). The non-parametric Mann–Whitney *U* test was utilized for parameters where the data were not normally distributed (Table 4). The 95 per cent confidence intervals are quoted. The statistical significance level was established at $P < 0.05$.

In order to evaluate measurement error, 20 dental casts and lateral cephalometric radiographs were selected at random and the experimental procedure was repeated by the same investigator. All measurements of the study models and cephalograms had intraclass correlation coefficients greater than 0.92 and 0.95, respectively.

Results

No statistically significant differences were found between gender groups, therefore the samples were pooled. Tables 2–4 show the results for the comparison of the Class II division 1 and division 2 groups. The only statistically significant difference between the groups for the dental cast measurements was found for mandibular intercanine width.

The cephalometric results revealed that SNB angle was responsible for the skeletal sagittal difference between the two groups. In addition, ANS–Me/N–Me ratio, Jarabak ratio, SN–MP angle, Y axis angle, and the sum of internal cranial angles all showed that the division 1 group had higher vertical proportions. The dental variables supported the selection criteria of the samples. Convexity angle, H angle, and the distances between the E line and the upper and lower lips indicated that the Class II division 2 group presented a more concave profile with a prominent chin, which was supported by the distance from pogonion to NB.

Discussion

This investigation studied the dento-skeletal characteristics of Class II patients using lateral cephalometric radiographs
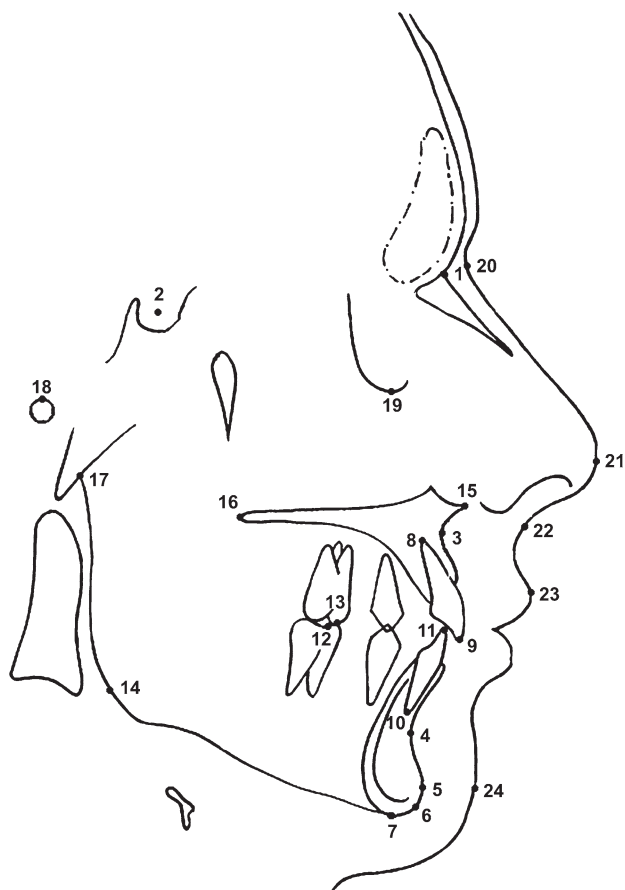
Figure 2 Cephalometric landmarks used in the study. 1 nasion, 2 sella, 3 point A, 4 point B, 5 pogonion, 6 gnathion, 7 menton, 8 apex of the upper central incisor, 9 incisal tip of the upper central incisor, 10 apex of the lower central incisor, 11 incisal tip of the lower central incisor, 12 tip of the mesial cusp of the lower first molar, 13 tip of the mesial cusp of the upper first molar, 14 gonion, 15 anterior nasal spine, 16 posterior nasal spine, 17 articulare, 18 porion, 19 orbitale, 20 soft tissue nasion, 21 tip of nose, 22 subnasale, 23 upper lip, 24 soft tissue pogonion.

Table 2 Comparisons of dental cast measurements of the study groups.

	Class II division 1		Class II division 2		*t*-test
	Mean	SD	Mean	SD	
Maxilla					
U3	34.12	2.71	33.96	2.66	ns
U4	40.56	3.27	40.38	2.39	ns
U5	45.69	2.93	45.55	2.38	ns
U6	50.68	3.06	51.50	2.91	ns
Mandible					
L3	27.52	1.65	26.02	1.83	***
L4	35.24	2.31	34.40	2.08	ns
L5	41.40	2.42	40.48	2.93	ns
L6	45.90	2.43	46.15	2.93	ns

SD, Standard deviation; ns, not significant; ***$P < 0.001$.

subjects were excluded since this may be a result of deleterious oral habits such as lip, tongue or thumb sucking and tongue thrusting, which can influence dental and skeletal morphology. For the definition of Class II division 2 cases, retroclination of the maxillary anterior teeth (at least of the two central incisors) and a deep bite were needed. The cephalometric dental findings for the upper and lower incisors supported the selection criteria of the groups.

The data on SNA angle indicated that the maxilla was normally positioned in both sample groups when compared with normative data (Riolo *et al.*, 1974). Likewise, Schwarz (1956) concluded in his studies that division 2 malocclusions revealed only dentoalveolar, not skeletal, discrepancies. In similar studies, Harris *et al.* (1972) and Pancherz *et al.* (1997) found a small SNA angle (maxillary retrusion) in Class II groups, whereas Rothstein (1971) and Rosenblum (1995) noted a protrusive maxilla. The differences in the methods of registering maxillary position may explain the various findings (Pancherz *et al.*, 1997).

SNB angle in the division 1 and 2 groups was 73.79 ± 3.18 and 76.42 ± 4.14 degrees, respectively. When compared with normative data (Riolo *et al.*, 1974) only the values for the Class II division 1 subjects suggested a retrognathic mandible. This finding is in agreement with Demisch *et al.* (1992) and Peck *et al.* (1998) who stated that in Class II division 2 cases, the mandible is not posteriorly displaced. On the contrary, in a study by Pancherz *et al.* (1997) SNB angle in both the division 1 and 2 groups was found to be smaller than the reference data. A reason for the dissimilar results for mandibular position may be explained by the age difference between the samples. Pancherz *et al.* (1997), who found that the division 2 group presented a smaller SNB angle than the division 1 group, concluded that this trend resulted from the constriction of the retroclined anterior maxillary dentition on the mandibular structures. Their results on the basal development of the mandible indicated by the increased values of SN–Pog in division 2 cases, is

and dental casts. Ninety untreated Class II division 1 and 2 patients between 13 and 22 years of age (mean 15.27 ± 2.48 years for division 1, 15.95 ± 3.25 years for division 2) were compared. The sample consisted of subjects in the permanent dentition to ensure minimal changes in arch widths due to growth (Bishara *et al.*, 1997).

Class II division 2 malocclusions are seen less frequently in the population; the sample size was therefore kept as large as possible, as previous studies have highlighted an insufficient sample size to be a limiting problem when evaluating Class II division 2 malocclusions (Demisch *et al.*, 1992; Peck *et al.*, 1998; Walkow and Peck, 2002).

The patient selection criteria were based only on the visual evaluation of the dental casts. In assigning Class II division 1 cases, the mean overjet (6.73 mm) in a Class II division 1 sample was taken as a guide (Baccetti *et al.*, 1997) and proclination of the maxillary anterior teeth with an overjet of more than 7 mm was adopted as the criterion to ensure a distinction from the division 2 group. Additionally, open bite

Table 3 Comparisons of normally distributed cephalometric measurements of the study groups.

	Class II division 1		Class II division 2		t-test
	Mean	SD	Mean	SD	
Skeletal measurements					
SNA (°)	80.52	3.66	81.54	4.10	ns
SNB (°)	73.79	3.18	76.42	4.14	**
ANB (°)	6.73	1.79	5.13	1.80	***
ANS–Me/N–Me (%)	56.72	2.85	54.25	2.58	***
Jarabak ratio (%)	64.28	4.23	67.84	5.79	**
Gonial ratio (%)	70.51	7.32	73.31	8.42	ns
S–Ar/Ar–Go (%)	80.02	9.27	81.15	10.54	ns
SN–MP (°)	35.94	5.98	30.59	6.40	***
SN–OP (°)	16.68	4.38	16.06	5.61	ns
SN–PP (°)	9.18	3.92	9.81	4.06	ns
SN–SAr (°)	126.08	5.43	124.45	5.19	ns
SA–ArGo (°)	143.06	6.46	144.37	7.79	ns
Σ (°)	395.95	5.99	390.59	6.40	***
Y axis (°)	62.02	3.47	59.84	3.70	**
Maxilliary height (°)	58.04	3.30	58.19	3.22	ns
Maxilliary depth (°)	89.39	3.14	89.29	3.25	ns
SAr (mm)	36.29	2.75	34.37	6.20	ns
SL (mm)	43.96	7.92	46.28	9.90	ns
SE (mm)	21.28	3.42	20.09	7.49	ns
Dental measurements					
U1–SN (°)	105.65	5.88	86.25	7.50	***
IMPA (°)	94.74	5.77	87.99	7.25	***
Overjet (mm)	10.02	2.37	3.67	1.28	***
Overbite (mm)	4.60	2.27	6.17	2.48	**
Soft tissue measurements					
Convexity angle (°)	168.47	5.48	173.11	5.00	***
Soft tissue convexity angle (°)	123.53	4.06	123.90	4.29	ns
Nasolabial angle (°)	112.92	8.23	115.66	7.88	ns
H angle (°)	22.31	4.22	17.45	5.05	***

SD Standard deviation; ns, not significant; **$P < 0.01$; ***$P < 0.001$.

Table 4 Comparisons of cephalometric measurements where data was not normally distributed.

	Class II division 1	Class II division 2	Mann–Whitney U test
	Median	Median	
Skeletal measures			
A–NA (mm)	−0.45	−1.05	ns
Go–Gn (mm)	75.90	73.30	ns
Pog–NB (mm)	2.55	3.40	**
Soft tissue measures			
UL–E line (mm)	0.15	−3.30	***
LL–E line (mm)	−0.05	−4.05	***

ns, not significant; **$P < 0.01$; ***$P < 0.001$.

parallel to the present findings related to chin projection. The present data also shows that the Class II division 2 group has a more concave profile with a prominent chin. Karlsen (1994) and Brezniak et al. (2002) also found that the chin was prominent in Class II division 2 subjects. On the other hand, Houston (1967) and Kerr et al. (1994) did not find a prominent chin in their Class II division 2 groups.

The vertical parameters in the present study demonstrate that Class II division 2 subjects have a more hypodivergent skeletofacial pattern than division 1 cases. Similar findings of a definite hypodivergent facial pattern with a flat mandibular plane angle have also been found (Houston, 1967; Pancherz et al., 1997; Peck et al., 1998). The fact that an anterior mandibular growth rotation occurs, especially in patients with deficient incisor support (Björk and Skieller, 1972; Karlsen, 1994), validates these results.

The soft tissue parameters of the upper lip–E line and lower lip–E line indicated a more concave profile of the lips in Class II division 2 subjects. According to Lapatki et al. (2002), this is the result of the lower lip exerting an excessive pressure on the anterior teeth, which makes division 2 treatment more prone to relapse (Selwyn-Barnett, 1991).

The only statistically significant difference among the groups for the dental cast measurements was found in mandibular intercanine width. There are studies in the literature on the dental arch characteristics of Class II subjects which either have results similar to the present findings regarding the constriction of mandibular intercanine distance in division 2 subjects (Buschang et al., 1994; Walkow and Peck, 2002), or differing results where

differences in molar widths between division 1 and division 2 groups have been noted (Moorrees *et al*., 1969; Buschang *et al*., 1994). It is suggested that a Class II division 2 malocclusion is characterized by normal transverse dimensions in the maxillary and mandibular posterior segments, but reduced intercanine arch dimension in the mandible (Walkow and Peck, 2002). The decrease in mandibular anterior arch width is probably a result of the severe overbite that inhibits forward mandibular dentoalveolar growth but not the strong basal and symphyseal growth in the Class II division 2 mandible (Peck *et al*., 1998).

Conclusion

Knowledge of dento-skeletal characteristics together with arch-width features of different types of Class II malocclusion would be helpful in determining treatment goals and successful treatment outcomes. In this investigation, the sagittal skeletal pattern of Class II division 2 subjects was found to be very similar to those with a Class I skeletal relationship, with no evidence of any mandibular restriction. In contrast, Class II division 1 subjects showed mandibular retrognathia. These findings suggest that orthodontists can rely on dentoalveolar mechanics in treating orthodontic problems concerning Class II division 2 subjects.

The only significant difference in the model analysis was the reduction of mandibular intercanine width in the division 2 subjects; this may be due to the deep overbite, retrusive maxillary incisors and excessive lip pressure which are the main keys to the frequently encountered problem of relapse in these patients.

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