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Class II malocclusion division 1: a new classification method by cephalometric analysis

ABSTRACT

Aim *The purpose of this study was to analyse the craniofacial and dentofacial skeletal characteristics in untreated subjects with Class II, division 1 malocclusion by mandibular retrusion and to identify different types and their prevalence.*
Materials and methods *In 152 subjects with Class II, division 1 malocclusion by mandibular retrusion, the differences were determined by lateral cephalograms analysis of variance and chi-square test, respectively. P<0.05 was considered significant. Seven types of mandibular retrusion were identified: three pure, dimensional, rotational and positional, and four mixed.*
Results *All patients showed significant inter-group differences with P between 0.005 and 0.001. The dimensional type was the most common (28.9%) and the rotational-positional type was the rarest (5.9%). The pure dimensional type had the shortest mandibular body; the pure rotational type had larger SN/GoMe and the lowest AOBO; the pure positional type presented the flattest cranial base, high AOBO. In the mixed types, dento-skeletal features changed depending on how the main types assorted.*
Conclusions *Identifying the type of mandibular retrusion is important for differential diagnosis in clinical practice and research.*

Keywords *Mandibular retrusion, Craniofacial growth, Class II Division 1, Cephalometric analysis*

Introduction

An analysis of the position of the maxillary and mandibular skeleton is essential for the planning of dentofacial orthopaedic treatment. Patients with Class II malocclusion commonly present clinical problems [McNamara et al., 1996], the main skeletal features observed are maxillary protrusion and mandibular retrusion, the latter being the most frequent [Henry, 1957; Perillo et al., 2010; Pancherz et al., 1997]. Another independent study [Goffman, 1957] and our previous report [Perillo et al., 2010] estimated that two thirds of patients with Class II, division 1 malocclusions have an associated skeletal dysplasia of clinical significance. Henry [1957] distinguished the genetically inherited underdeveloped micromandible that is associated with a chinless type of face. It has been reported that patients with Class II malocclusion have significantly shorter mandibles during both infancy and adolescence than individuals with no malocclusion [Kerr and Hirst, 1987; Varrela, 1998]. There remains a problem with terminology [Henry, 1957; Ngan et al., 1997]. It is not sufficient to describe a sample as showing a Class II, division 1 malocclusion. The term "mandibular retrusion" describes a large, heterogeneous and poorly defined group, as already reported in 1980 [Moyers et al., 1980]. Too many terms, such as micromandible, underdeveloped, retropositioned, retruded, retrusive, distally positioned and posteriorly positioned mandible, are still used as synonyms [Ngan, 1997].

The aim of the study was to analyse the dento-skeletal characteristics of Class II, division 1 malocclusion associated with mandibular retrusion.

Materials and methods

Initial standardised lateral cephalograms from 200 consecutive patients with Class II, Division 1 malocclusions, which were provided by the Second University of Naples, were analysed. Only patients with dento-skeletal Class II, Divison 1 malocclusion associated with mandibular retrusion were selected. Specifically, an ANB angle of more than 4° in association with SNB and SNA angles of less than 78° and 84°, respectively, was required. Children with maxillary protrusion or a low quality lateral cephalogram or who had undergone previous orthodontic treatment were excluded. The protocol generated a sample of 152 untreated patients, 68 boys and 84 girls. The mean age of the participants was 9 years (range 5.3 to 13.4 years). The stage of cervical vertebral maturation ranged between C1 and C3.

Cephalometric analysis

Each film was traced by one investigator (G.P.) onto 0.003-inch frosted acetate with a 0.3 mm lead pencil. Images of bilateral structures were bisected and

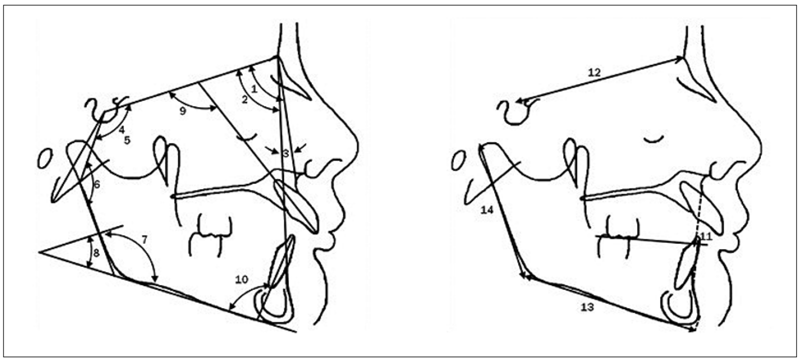

FIG. 1 Angular and linear measurements
Angular: (1) SNA; (2) SNB; (3) ANB; (4) NSAr; (5) NSBa; (6) SArGo; (7) ArGoMe; (8) SN/GoMe; (9) I/SN and (10) i/GoMe. Linear: (11) AOBO; (12) SeN; (13) GoPg; (14) CoGo.

measurements were taken to the nearest 0.5 mm or degree. The following measurements were obtained from the functional cephalometric analysis [McNamara et al., 1996; Moyers et al., 1980] (Fig. 1): the angles SNA, SNB, ANB, NSAr, NSBa, SArGo, ArGoMe, SN/GoMe, I/SN, and i/GoMe, the Wits appraisal (AOBO) [Rakosi, 1982], the lengths of the anterior cranial base (SeN), mandibular ramus (CoGo), and mandibular body (GoPg, projected on the mandibular plane), and the relationship between GoPg and SeN. The cephalometric parameter GoPg was considered to be the distance between the gonion and pogonion when projected perpendicularly on the mandibular plane. Ideally, the mandibular base should be 3 mm longer than the SeN up to the 12th year of age and 3.5 mm longer thereafter [Frohlich, 1962].

Statistical analysis

For continuous variables, the mean and standard deviation (SD) were calculated and compared by analysis of variance. For categorical variables, the absolute number and percentage were reported and compared using the chi-square test. Data were analysed with the Statistical Analysis System (version 8.2, SAS Inc, Cary, NC). P<0.05 was considered statistically significant. Cephalograms from 20 patients were selected at random and analysed again on a different day. The error standard deviation of each measurement was calculated using Dahlberg's formula ($\sqrt{\Sigma D^2/2N}$), where D is the difference between the first and second measurements and N = 20, the number of double determinations [Jacobson, 1976; Dahlberg, 1940; Dibbets, 1996].

Results

The selected sample (Table 1) comprised 152 patients, 68 boys and 84 girls, with a mean age of 9.0 years. All of the patients had a skeletal Class II malocclusion with increased ANB (6.5° ± 1.4) and AOBO (3.3 mm ± 2.6) caused by mandibular retrusion (SNB 73.0 ± 2.6), without maxillary protrusion (SNA 79.5 ± 2.8). The standard deviations for each measurement in the present study are summarised in Table 2. For each cephalometric variable, the mean and standard deviation (SD) are shown (Table 3) to illustrate the number and percentage of the total sample that deviated by at least 1 SD above or below the mean value. In almost half (46.5%) of the patients, the value of SNA was at least 1 SD below the normal value; the remainder had a normal angle. Thus, a large percentage of the sample showed maxillary retrusion associated with mandibular retrusion. The divergency angle (SN/GoMe) was more than 1 SD above the normal value in 52.0% of the participants, whereas few children (3.3%) presented a value that was more than 1 SD below the norm. The cranial base angle (NSBa) and the saddle angle (NSAr) were greater than the norm in 44.7% and 36.2% of the subjects, respectively. The articular angle (SArGo) did not deviate from the norm in 66.5% but was greater in 22.4% of the patients. The gonial angle (ArGoMe) was normal in 75%, but was lower in 21.7% of the sample. Dental compensation was common, with proclined lower incisors in 61.8% and retroclined maxillary incisors in 24.3% of the participants. The value for AOBO was

Male 68 (44.7%) Female 84 (55.3%) Overall 152	
Age, year	9.0 (1.5)
SNA	79.5 (2.8)
SNB	73.0 (2.6)
ANB	6.5 (1.4)
NSAr	126.9 (5.5)
NSBa	133.2 (5.3)
SArGo	144.6 (6.6)
ArGoMe	125.2 (5.9)
SN/GoMe	36.3 (4.9)
I/SN	104.0 (7.3)
i/GoMe	95.5 (6.2)
AOBO	3.3 (2.6)
SeN	68.6 (3.8)
GoPg/SeN	0.2 (3.8)

TABLE 1 Characteristics of subjects

MEASURE	ERROR SD
Angular	
SNA	0.49
SNB	0.54
ANB	0.64
NSAr	0.41
NSBa	0.35
SArGo	0.30
ArGoMe	0.32
SN/GoMe	0.44
I/SN	0.39
i/GoMe	0.23
Linear	
AOBO, mm	0.21
SeN, mm	0.37
GoPg, mm	0.44
CoGo, mm	0.23

TABLE 2 Error study.

greater than the norm in 60.5% of the sample. Finally, 80.3% of the sample had a short mandibular body.

Different types of skeletal mandibular retrusion and their prevalence

On the basis of the main skeletal mandibular features, seven types of mandibular retrusion were identified: three pure and four mixed, which were derived by association.

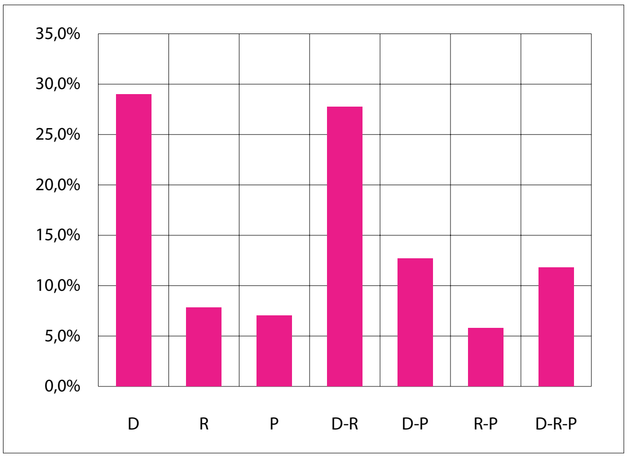

FIG. 2 Prevalence of skeletal mandibular retrusions types D (dimensional); R (rotational); P (positional); D-R (dimensional-rotational); D-P (dimensional-positional); R-P (rotational-positional); D-R-P (dimensional-rotational-positional).

1. Dimensional mandibular retrusion (D), characterised by a short mandibular body.
2. Rotational mandibular retrusion (R), associated with a clockwise mandibular rotation.
3. Positional mandibular retrusion (P), with a posterior mandibular position.
4. Dimensional–rotational mandibular retrusion (D-R).
5. Dimensional–positional mandibular retrusion (D-P).
6. Rotational–positional mandibular retrusion (R-P).
7. Dimensional–rotational–positional mandibular retrusion (D-R-P).

The prevalence of these different types of mandibular retrusion is illustrated in Figure 2. The

	NORMAL RANGE	WITHIN NORMAL RANGE	ABOVE NORMAL RANGE	BELOW NORMAL RANGE
		n (%)	n (%)	n (%)
SNA	82 ± 2	81 (53.3)	0 (0.0)	71 (46.7)
SNGoMe	32 ± 4	68 (44.7)	79 (52.0)	5 (3.3)
NSAr	123 ± 5	87 (57.2)	55 (36.2)	10 (6.6)
NSBa	129 ± 5	79 (52.0)	68 (44.7)	5 (3.3)
SArGo	143 ± 6	101 (66.5)	34 (22.4)	17 (11.2)
ArGoMe	128 ± 7	114 (75.0)	5 (3.3)	33 (21.7)
I/SN	102 ± 2	38 (25.0)	77 (50.7)	37 (24.3)
i/GoMe	90 ± 3	48 (31.6)	94 (61.8)	10 (6.6)
AOBO	0 ± 2	60 (39.5)	92 (60.5)	0 (0.0)
GoPg/SeN	> 3	30 (19.7)	-	122 (80.3)

TABLE 3 Distribution of the dento-skeletal characteristics of the sample based on range.

dento-skeletal characteristics of the different types of mandibular retrusion are illustrated in Table 4. P-values from 0.005 to 0.001 were obtained for most of the cephalometric measures, with the exception of the ANB angle, upper incisor inclination, and length of the mandibular ramus. No differences were observed in relation to age or sex.

Discussion

In the present study, we analysed the dento-skeletal characteristics of Class II, division 1 malocclusion associated with mandibular retrusion in order to identify different types of mandibular retrusion and determine their prevalence. Seven types of mandibular retrusion were identified.

The short mandible was the most common characteristic (identified in 80.3% of patients), which might explain why mandibular retrusion is usually characterised by a short mandible. It was found more often in combination with other mandibular features (mixed types; 51.3%) than alone (pure type; 28.9%). The types of mandibular retrusion that were characterised by a short mandible were termed dimensional types. The dimensional type had proclined lower incisors that could camouflage, at least partially, the mandibular retrusion. Moreover, in this type, we found that the AOBO was greater than the norm. In the rotational type, an average AOBO was observed, because the steeper the occlusal plane, the closer the projected A and B points [Baccetti et al., 2009].

Moreover, the SArGo was slightly larger than the norm because this angle is slightly greater in patients with vertical growth than in those with horizontal growth at 9 years [Buschang et al., 1988].

Finally, the proclination of the lower incisors was reduced, as compared with the normal level, but the

	Pure dimensional (n=44)	Pure rotational (n=11)	Pure positional (n=10)	Dimensional –rotational (n=42)	Dimensional – Positional (n=19)	Rotational Positional (n=9)	Dimensional – rotational – positional (n=17)	p-value
Male gender, n (%)	Positional (n=19)	Rotational	p-value	20 (47.6)	10 (52.6)	3 (33.3)	6 (35.3)	0.298
Age, year	Positional (n=9)	Dimensional – rotational – positional (n=17)	p-value	8.6 (1.3)	9.2 (1.9)	9 (1.2)	9.2 (1.7)	0.421
SNA	(n=11)	Pure	79.1 (2.5)	79.9 (2.6)	79.1 (2.6)	78.1 (2.1)	76.9 (3.4)	<.0001
SNB	positional	74 (1.9)	72.9 (2.2)	73.2 (2.4)	72.5 (2.1)	71.6 (2.6)	70.3 (3.2)	<.0001
ANB	(n=10)	Dimensional – rotational	6.3 (1.2)	6.7 (1.5)	6.6 (1.5)	6.5 (0.9)	6.6 (1.4)	0.896
SNGoMe	(n=42)	Dimensional –	30.8 (4.8)	40.1 (2.8)	31.6 (3.8)	40.4 (3)	40.1 (3.3)	-
NSAr	positional	125.2 (2.4)	133.6 (3.4)	123.6 (3.9)	132 (2.8)	133.6 (2.7)	132.2 (3)	-
NSBa	(n=19)	Rotational	139 (3.4)	130.6 (4.5)	136.8 (3.6)	137.6 (2.4)	138.6 (3.4)	<.0001
SArGo	positional	151.9 (3.7)	140.4 (6)	147 (5.8)	137.9 (6.4)	141.5 (6.1)	142.5 (5.5)	<.0001
ArGoMe	(n=9)	Dimensional – rotational – positional	119.2 (5.7)	129.2 (5)	123.8 (6.2)	125.2 (7.2)	126.1 (4.7)	<.0001
I/SN	(n=17)	p-value	104.7 (7.6)	104.4 (6.4)	103.2 (5.9)	100.9 (7.6)	101 (8)	0.178
i/GoMe	96.4 (5.8)	91.8 (5.6)	100.9 (8)	93.9 (5.5)	97.3 (6.2)	93.5 (8.1)	95.3 (4.9)	0.006
AOBO	4.1 (2.7)	1.6 (2.6)	3.5 (2.6)	2.8 (2.4)	4.3 (2.3)	1.7 (2.4)	2.9 (2.1)	0.005
Se-N	69.5 (3.8)	65.9 (2.6)	67.5 (3.4)	69 (3.3)	69.3 (4.3)	65.2 (2.7)	68.8 (3.9)	0.005
Go-Pg	68.1 (4)	71 (2.7)	73.8 (3.3)	67.9 (3.5)	68.7 (4.3)	70.6 (2.2)	68.2 (4.2)	<.0001
Go-Pg / Se-N	-1.4 (3.4)	5.1 (1.3)	6.3 (2.2)	-1.1 (2.7)	-0.7 (2.3)	5.3 (1.5)	-0.6 (3.2)	-
Co-Go	52.2 (4.3)	51.8 (4.5)	53.1 (2.9)	50.6 (4)	53.6 (3.8)	51 (3.4)	49.5 (6.1)	0.053

TABLE 4 Dento-skeletal characteristics of the different types of mandibular retrusions.

inclination of the upper incisors was normal. The largest values for the NSBa and NSAr, and therefore the flattest cranial base morphology, were found in the positional type. This finding was in agreement with Dibbets [1996] and Giuntini [et al., 2008], but not with Rothstein and Yoon-Tarlie [2000] who reported that the mandibles of Class II patients and control subjects were identical with respect to size, form, and position between the ages of ten and 14 years. In addition, the percentage of subjects with an increased NSBa was higher than that of those with an increased NSAr, which suggests that, even in a flat cranial base, the glenoid cavity can move anteriorly to compensate partially for a distal position of the mandible. In the mixed types, the dento-skeletal features depended on how the main forms were combined. Therefore, some of the values were higher than the norm but others were lower, because the characteristic of one mandibular type camouflaged those of the others or made them more marked. Both mixed types mentioned above had significantly lower SNA and SNB angles, which suggests that mandibular and maxillary retrusion may have a common genetic pattern. The analysis of the facial growth patterns is vital in terms of predicting the growth expectations of patients in order to enable the planning of treatment and its timing and to evaluate treatment outcomes in growing patients. The characteristics of cranial base angulation can influence the overall craniofacial pattern in patients with different forms of malocclusion [Bjork, 1955]. Closure of the cranial base angle has been associated with a tendency towards Class III dento-skeletal disharmony, whereas obtuse cranial base angulation is more prevalent in Class II malocclusion [Kerr and Hirst, 1987; Baccetti et al., 1997]. The clinical relevance of this finding is emphasised when we consider that therapeutic modalities such as functional jaw orthopaedic procedures have the greatest effectiveness if the type of mandibular retrusion is identified correctly [Marsico et al., 2011; Tecco et al., 2005].

Conclusion

In the present study, we demonstrated that patients with Class II malocclusion were characterised by an obtuse cranial base angle, a retruded mandible, an excessive value for the Wits appraisal, and retroclined mandibular incisors, in addition to the standard occlusal features of Class II, Division 1 malocclusion (excessive overjet and distal molar relationship).

The significant growth deficiency in mandibular length that is associated with Class II malocclusion suggests that treatment strategies should be aimed at enhancing mandibular growth as a component of Class II correction during the pubertal phases.

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