# Morphological distribution of Class II malocclusions according to skeletal pattern in an adult sample of the School of Dentistry of the University of Chile

*Distribución Morfológica de las clases II según su naturaleza esqueletal en una muestra de población adulta de la Facultad de Odontología de la Universidad de Chile*

*Distribuição morfológica das más oclusões de classe II de acordo ao padrão esquelético, em uma amostra da população adulta da Faculdade de Odontologia da Universidade do Chile*

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## Abstract

**Objective:** To determine the morphological distribution of Class II malocclusions according to skeletal pattern in an adult sample of the School of Dentistry of the University of Chile.
**Materials and methods:** The experimental sample consisted of 220 individuals over 18 with an ANB angle greater than 4°. SNA and SNB angles were measured to assign the Class II skeletal pattern.
**Results:** The most frequent skeletal pattern was the mandibular pattern followed by the maxillary pattern. In addition, three new skeletal patterns were found. They have not been explicitly described before in the relevant literature (bi-protrusion, bi-retrusion and within normal range).
**Conclusions:** The most frequent Class II malocclusion skeletal pattern in our study was the mandibular pattern. The bi-retruded and bi-protruded variants should be incorporated into the skeletal diagnosis, particularly the bi-retruded variant, due to its significant high frequency and clinical relevance.

**Keywords:** cephalometric, II malocclusion.

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## Resumen

**Objetivo:** Determinar la distribución morfológica de las Clases II según su naturaleza esqueletal en una muestra de población adulta de la Facultad de Odontología de la Universidad de Chile.

**Materiales y métodos:** La muestra experimental estuvo compuesta por 220 telerradiografías laterales de cráneo de individuos mayores de 18 años con ángulos ANB mayores a 4°. Para asignar la naturaleza esqueletal se midieron los ángulos SNA y SNB.

**Resultados:** Se obtuvo que la naturaleza esqueletal más frecuente fue la mandibular seguido por la maxilar. Además, se obtuvieron tres nuevas naturalezas esqueletales las cuales, según el análisis de la literatura pertinente, no habían sido descritas explícitamente con anterioridad (bi-protruida, bi-retruida y en norma).

**Conclusiones:** La naturaleza esqueletal de las maloclusiones Clase II más frecuente en nuestro estudio fue la naturaleza mandibular. Las variantes bi-retruida y bi-protruida deberían ser incorporadas en el diagnóstico esqueletal, especialmente la variante bi-retruida, debido a su significativa alta frecuencia y relevancia clínica.



**Palabras clave:** Cefalometría, maloclusión Clase II.



## Resumo

**Objetivo:** Determinar a distribuição morfológica da má oclusão de Classe II de acordo ao padrão esquelético, em uma amostra da população adulta da Faculdade de Odontologia da Universidade do Chile.

**Materiais e Métodos:** A amostra experimental foi composta de 220 indivíduos acima de 18 anos de idade, com ângulo ANB maior que 4°. Os ângulos SNA e SNB foram medidos para determinar o padrão esquelético da Classe II.

**Resultados:** Foi observado que o padrão esquelético mais frequente foi o mandibular e depois maxilar. Além disso, foram obtidos três novos tipos de padrões esqueléticos que, de acordo com a análise da literatura relevante, não haviam sido explicitamente descritos anteriormente: bi-protrusão, bi-retrusão e em norma.

**Conclusões:** O padrão esquelético mais frequente das más oclusões de Classe II do nosso estudo foi mandibular. As variantes bi-protrusão e bi-retrusão deveriam ser incorporadas no diagnóstico esquelético, especialmente a variante de bi-retrusão, devido à sua significativa frequência elevada e relevância clínica.



**Palavras-chave:** Cefalometria, má oclusão de Classe II.


## Introduction

Dental malocclusion is one of the most prevalent disorders affecting the oral cavity after dental caries and periodontal disease. It ranks third among the world priorities of dental conditions of public health relevance.[1,2] It is defined as a variation from the typical occlusal pattern or a variation from the normal range of growth and morphology, which may affect the teeth, the bone skeleton, or both.[1,2] Malocclusion is not a pathology in itself but a variation that may or may not be associated with pathological conditions.[1]

In 1899, Angle classified malocclusions. This classification is so straightforward that it remains one of the leading classification systems in orthodontics. Angle uses the term “class” to refer to the sagittal relationships between the dental arches, and its indicators are I, II, and III. This system is widely accepted and allows orthodontists from different parts of the world to communicate fluently.[3,4] Having said that, this classification only describes tooth relationships. It took some time in the history of orthodontics for lateral skull teleradiography and, concomitantly, conventional cephalometric analysis to be adopted to determine the skeletal bases of malocclusion.[5] In this way, the advent of cephalometry helped us understand that malocclusions are not only dental in nature but that the position or size of the maxilla and mandible might affect the relationship between the upper and lower teeth.

Specifically, Class II malocclusions would result from a sagittal disproportion, both in size and position of the jaws. The relevant research shows that Class II malocclusions could be due to three well-determined skeletal situations: a) a protruded maxilla; b) a smaller size or retruded mandible; and c) a combination of the two.[6-11]

Studies on the prevalence of malocclusions have been based mainly on the sagittal relationship of the dental arches.[1,12-14] According to the arches, Class II represents between 5% and 29% of the population.[6,15] Studies on this subject are scarce and include varying data, particularly in Chile. Burgos determined that Class II prevalence in a sample of 185 cases (children and adolescents) was 21.7%.[16] Aguirre showed a higher frequency of skeletal Class II in a sample of 92 individuals: 44.6%.[17] In another study, Iturriaga and Whittle determined that Class II prevalence in a sample of 1000 cases was 31% in men and 25% in women.[18]

As mentioned above, some studies conducted in Chile have aimed to establish the prevalence and frequency of malocclusions. However, none of them have determined their skeletal pattern, especially Class II malocclusions. This study aimed to determine the morphological distribution of Class II malocclusion according to its skeletal component, or what we will refer to as "skeletal pattern," in an adult sample from the School of Dentistry of the University of Chile.

## Materials and methods

We used an anonymized database of lateral skull T-X-rays (teleradiography) kept at the Center for Quantitative Analysis in Dental Anthropology (CA2) of the School of Dentistry, University of Chile. The records belonged to patients attending the Dental Clinic of the School of Dentistry. A total of 1,011 lateral skull T-X-rays were examined. We selected those of individuals over 18 and with no history of previous orthopedic or orthodontic treatment. The T-X-rays showing an ANB angle greater than 4° (skeletal diagnosis) and normal or increased proclination of the upper incisors showed Class II malocclusions. The T-X-rays showing upper incisor retrusion were excluded. The resulting sample included 220 individuals (161 women and 59 men).

The SNA and SNB angles were measured to assign each T-X-ray to a skeletal pattern. The skeletal pattern was maxillary when the SNA angle was greater than 84°, and the SNB angle fell within the cephalometric range, i.e., between 78° and 82°. The skeletal nature was mandibular when the SNB angle was lower than 78°, and the SNA angle was within the normal range, i.e., between 80° and 84°. Finally, there was a mixed skeletal pattern when the SNA angle was above the normal range, and the SNB angle was below the normal range (Table 1, Figure 2). The angles were measured with TpsDig2 (V. 2.31, 2017) software. The same operator selected the T-X-rays and measured the angles.

**Table 1:** Criteria for assigning skeletal pattern based on SNA and SNB angles.

| Skeletal pattern | SNA angle | Ángulo SNB |
|---|---|---|
| Maxillary | > 84° | 78° - 82° |
| Mandibular | 80°- 84° | < 78° |
| Mixed | > 84° | < 78° |

To estimate the intraobserver error, we tested the null hypothesis 1 (H01), which states H01: μ1 = μ2, where μ is the parametric mean of the angle values [1] and their respective repeated measures [2]. We conducted an Anova test on repeated measures, considering male and female samples separately for each angle.

**Distribution of skeletal classes according to sex**:

In this study, we tested the null hypothesis 2 (H02) to determine the effect of the sex variable. This hypothesis states that H02: μ1 = μ2, where μ is the parametric mean of the number of skeletal classes, 1 corresponding to males and 2 to females. We conducted the non-parametric Chi-square test ($Chi^2$).

Statistical analyses were performed with PAST (V. 4.03) software (paleontological statistical software package for education and data analysis).

# Results

No statistically significant differences were observed between the original and the repeated measures performed by the same observer (FV) (men's SNA): $F(1,18)=0.71442$, $p=0.1268$; women's SNA: $F(1,18)=1.513$, $p=0.2499$; men's SNB: $F(1,18)=3.309$, $p=0.1023$; women's SNB: $F(1,18)=3.799$, $p=0.08308$; men's ANB: $F(1,18)=0.0016$, $p=0.9687$; women's ANB: $F(1,18)= 0.6723$, $p=0.4334$).

We measured the SNA and SNB angles and assigned each T-X-ray to a specific skeletal pattern. We observed, in both men and women, a significant number of cases that could not be assigned to any of the previously established patterns (maxillary, mandibular, or mixed). We found three new patterns by analyzing the SNA and SNB angular measurements of these cases. The first pattern we called "within normal range." The SNA and SNB angular values fell within the average values. The second pattern found was named "bi-retruded." Here, the SNA values were lower than 80° and the SNB values, lower than 78°. Finally, we found a third pattern, "bi-protruded," in which the SNA and SNB angles were greater than 84° and 82°, respectively. (Table 2, Figure 1, Figure 3).

The differences in the ratio of skeletal patterns according to sex were statistically non-significant ($Chi^2$ (g.l.5)=7.8021, $p=0.16748$, p Monte Carlo=0.1667, N permutations=9999).

**Table 2:** Distribution according to the skeletal pattern of Class II malocclusions

| Skeletal pattern | Women | Men | Total |
|---|---|---|---|
| Maxillary | 41 | 18 | 59 |
| Mandibular | 56 | 26 | 82 |
| Mixed | 11 | 4 | 15 |
| New patterns<br>- Within normal range<br>- Bi-retruded<br>- Bi-protruded | <br>8<br><br>32<br>13 | <br>2<br><br>3<br>6 | <br>10<br><br>35<br>19 |

**Figure 1:** Distribution according to the skeletal pattern of Class II malocclusions. The results of men and women are considered together because there is no statistically significant difference in the ratio of skeletal patterns.

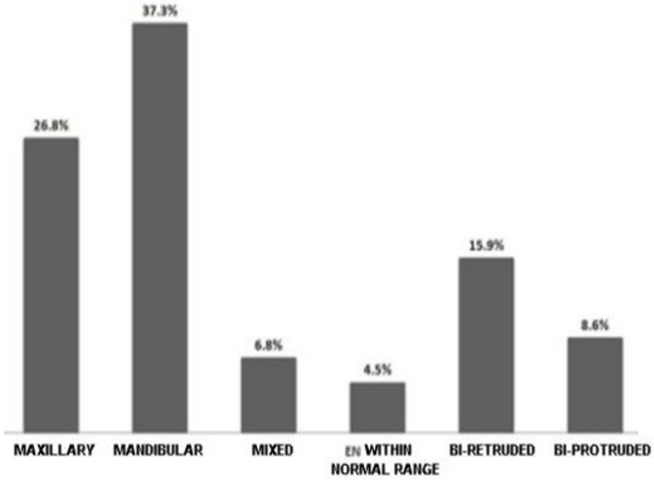



**Figure 2:** Simplified diagrams of SNA and SNB measurements in individuals of maxillary, mandibular, and mixed skeletal patterns.

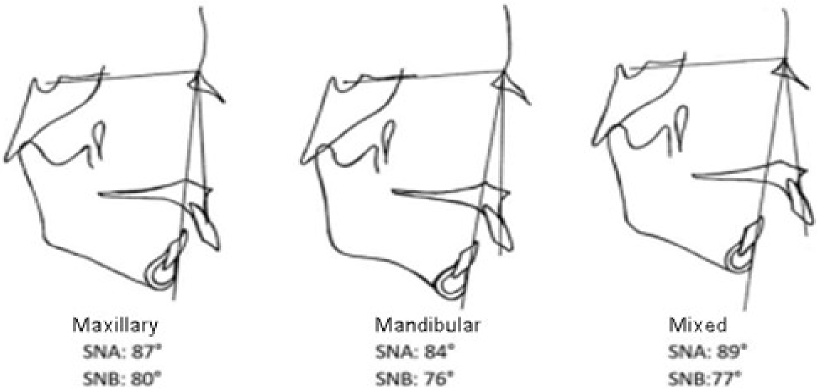
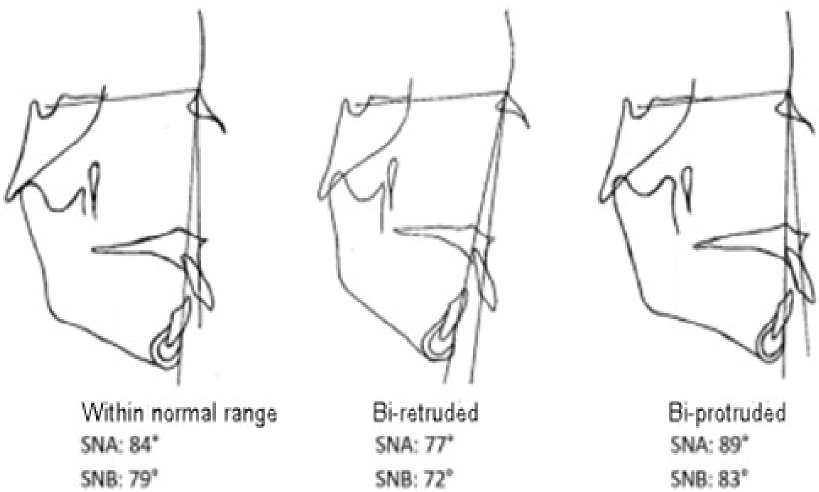



**Figure 3:** Simplified diagrams of SNA and SNB measurements in individuals within normal range, bi-retruded and bi-protruded skeletal pattern.



## Discussion

An analytical, cross-sectional, and quantitative study was conducted using lateral skull T-X-rays to determine the morphological distribution of Class II malocclusions in adult patients according to their skeletal pattern in a sample from the School of Dentistry, University of Chile. This was done with an anonymized database held at the Center for Quantitative Analysis in Dental Anthropology of the School of Dentistry, University of Chile.

There is no agreement in the literature regarding the origin or etiology of Class II malocclusions in terms of jaw growth. Some authors state that this sagittal disproportion would be caused mainly by a retruded jaw.(8,9,11) Some attribute it to a protruded position of the maxilla with respect to the skull,(6,7) and others to a combination of alterations that may affect both structures.(10) The prevalence of each of these patterns has not been clearly established.

Our results indicate that Class II malocclusion is mainly attributed to altered mandibular position or size in both men and women. These results agree with Ardani et al., who studied an Indonesian adult population and concluded that the mandibular pattern is the most frequent one.(15) In turn, Helder and Buschang studied French-Canadian adolescents and found that the increase in the ANB angle observed in Class II individuals is mainly due to a decrease in the SNB angle.(11)

In contrast, Hassan studied a Saudi population. In a sample of 85 children aged 10-13, he found that the maxilla was significantly more prognathic in the Class II group due to an increased ANS angle.(6) Rosenblum found that 56.6% of individuals with Class II malocclusion had maxillary protrusion, and only 26.7% had mandibular retrusion.(7)

This discrepancy can be attributed to different factors. One of them is using less precise criteria, such as patient selection based on dental rather than skeletal relationships. In addition, studying growing individuals may introduce a confusion factor.(6) The final size and position of the mandible is established towards the end of the individual's growth and development process. As the mandible is the last structure to mature, studying an adult sample would be a better strategy to determine the skeletal basis of Class II malocclusions more reliably.(19) Based on this, the mandible would be the primary determinant of malocclusions since it would be under the greatest environmental and epigenetic influence.(11)

Another factor to consider is the participants' ethnicity. Ardani et al. compared their results with other studies conducted in different populations (Canada, China, Nepal, Italy, Iraq, and Saudi Arabia). They found that facial pattern variation in Class II skeletal pattern may be affected by ethnicity.(15)

Our results show that Class II is caused mainly by a retruded mandible. However, it could also be explained by a protruded maxilla or a combination of alterations in the position and size of both maxilla and mandible. Ardani et al. found that the most frequent skeletal pattern is the mandibular one, followed by excessive maxilla, then a mixed pattern, and finally by normal maxillary and mandibular length.(15)

Conversely, some authors categorically attribute Class II malocclusions only to a retruded mandible(9,11) or only to a prognathic maxilla,(6) excluding other potential etiologies. This could be explained because the results are analyzed based on the averages of the total measurements. It is essential to consider all the skeletal patterns, even if they are rare, as they are a determining factor when diagnosing and planning personalized treatment.

One of the main findings of this work is the description of three new skeletal patterns, which, according to the analysis of the relevant literature, had not been explicitly described before. While orthodontists may have already detected these Class II presentations, they do not appear in the literature as clearly as the others do. Nevertheless, some studies may potentially be indirectly comparable to ours. Sidlauskas et al. evaluated 86 patients aged between 9 and 12. They found 8% of Class II individuals presenting maxillary retrognathia, which was determined when the ANS angles were lower than 77°. However, this percentage would be considerably higher if these authors had considered angles lower than 80° maxillary retrognathia, as in our study. All the patients in that study had ANB angles greater than 4°, so we could deduce that this same percentage of patients had a bi-retruded Class II malocclusion.[20] McNamara studied 277 patients aged 8 to 11 to determine the nature and frequency of specific components that may contribute to a Class II occlusal relationship. He found a high frequency of cases with maxillary retrusion (48.9%).[21] However, this study's inclusion criteria were based on a dental and not a skeletal diagnosis. Nor did we distinguish between Class II division 1 and Class II division 2, as these would be two morphologically different entities that should be considered as two extreme patterns of a retruded mandible variation.[22] Finally, Pancherz compared Class II division 1 and Class II division 2 malocclusions in children aged 8 to 10 and 11 to 13. He observed that 15% of the 8 to 10 group, and 13% of the 11 to 13 group, had a retruded maxilla. Maxillary retrusion appears when the ANS angle is lower than or equal to 76°.[10]

The literature does not support the existence of sexual dimorphism in cephalometric studies.[9,10,23,24] However, the high expression of bi-retruded Class II in women compared to men in our results is striking. This would reflect the proportion of both sexes in the total sample regardless of the skeletal pattern.

The bi-retruded group arouses particular interest regarding the impact of mandibular and maxillary retrusion on the upper airway. It is essential to study the upper airway and its relationship with mandibular position and size in orthodontic diagnosis due to its association with obstructive respiratory disorders, especially sleep apnea.[25] Severe mandibular deficiency has been associated with narrowed pharyngeal airway, which increases the likelihood of impaired respiratory function and possibly causes disorders such as rhoncopathy, increased upper airway resistance syndrome and obstructive sleep apnea-hypopnea syndrome.[26] Nadja e Silva et al. evaluated airway dimensions in patients with Class II skeletal malocclusion with the lateral cephalograms of 80 individuals aged 10 to 17. They found that the size of the oropharynx and nasopharynx, as well as the mandibular position and length, were smaller in Class II individuals. There was a positive correlation between the size of the oro-nasopharynx and different cephalometric measurements characteristic of Class II, including the SNB angle.[25] If a patient with a retrognathic maxilla also presents a retruded mandible, we would expect a greater involvement of signs and symptoms of upper airway obstructive problems. This aspect is fundamental in the therapeutic indication of orthopedic and surgical bimaxillary advancement.[25] Bimaxillary advancement surgeries have proven to be beneficial in terms of increased upper airway size, improved oximetric indicators, and better quality of life as measured with the Epworth Sleepiness Scale.[27,28]

Considering this bi-retruded skeletal variant of Class II is relevant because it enriches the diagnosis and guides the treatment, where bimaxillary sagittal modifications are required to achieve the right dento-skeletal balance. Combined surgical and orthodontic treatments have improved considerably in recent decades due to increased diagnostic capabilities, a better understanding of the interaction between the various components of the stomatognathic system, and the ability to implement customized treatments.[29]

# Conclusion

The most frequent Class II malocclusion skeletal pattern in our study was the mandibular pattern, followed by the maxillary pattern. Due to their great clinical relevance, the bi-retruded and bi-protruded maxillary patterns should be included in the description of the Class II skeletal patterns, especially the bi-retruded variation. Class II malocclusion presents various dental and skeletal morphologies that clinicians should recognize since optimal treatment and correction of sagittal skeletal discrepancies should be based on the individualized diagnosis of every patient.

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**Authorship contribution**
1. Conception and design of study
2. Acquisition of data
3. Data analysis
4. Discussion of results
5. Drafting of the manuscript
6. Approval of the final version of the manuscript

FV has contributed in 1, 2, 3, 4, 5, 6.
CB has contributed in 2, 3, 4.
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