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Research Article

# Respiratory Repercussions Due to Mandibular Advancement in Children and Adolescents with Mandibular Class II Malocclusion: A Retrospective Longitudinal Study

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## Abstract

To test the improvement in airway patency after mandibular advancement with functional appliances as a treatment for growing patients with skeletal Class II caused by mandibular retrognathism. Determining which functional mandibular advancement appliance has the greatest effect on the augmentation of the upper and lower pharyngeal airways. A series of measurements were made according to Arnett's analysis in the lateral teleradiographies of the skull using the Nemoceph program to evaluate how the upper and lower airways are modified at sagittal level pre- and post-treatment, with different types of mandibular advancement appliances and in growing patients with age ranges from 8 to 15 years. There are statistically significant differences in craniometric points A, MCI and Pg in contrast to other studies with the same cephalometric analysis, where craniometric point B presented a greater increase of mm after advancement. There is an improvement in mandibular Class II skeletal malocclusion after the use of mandibular advancement appliances, and more changes are observed in the A, MCI and Pg points, confirming improvement in upper air patency.

**Keywords:** Airway permeability; Class II skeletal; Mandibular advancement; CBCT; Telerradiographs; Cephalometric analysis

## Introduction

Class II bony malocclusion is one of the most common malocclusions in growing patients and is defined mainly by the presence of a retrognathic mandible or small mandible in relation to the maxillary complex [1,2], or excess maxillary growth and a normopositioned mandible [3].

The prevalence of Class II varies in different ethnic groups, occurring in 48.1% in whites and 20% among blacks [4,5]. McNamara also reported that up to 85% of patients with Class II malocclusion have some component of mandibular deficiency underlying the Class II skeletal discrepancy [6,7].

A great diversity can be seen in the distribution of the components that make up Class II malocclusion. Nevertheless, two recurrent problems are identified: mandibular skeletal retrusion and increased vertical dimension. Likewise, transverse maxillary constriction occurs very frequently, underlining the need not to treat Class II malocclusion as a single diagnostic entity [8].

The ideal treatment for class II patients in the process of growth or when they still present inherent growth would consist of stimulating anterior mandibular growth or restricting maxillary growth in both directions [9].

Among all craniofacial disharmonies, skeletal class II is the malocclusion most frequently associated with upper airway narrowing. There seems to be consensus that maxillary protrusion increases the length of the upper airway and mandibular retrusion is related to its narrowing [3].

The Pharyngeal Airway (PA) is mainly composed of three parts: the nasopharynx, the oropharynx and the hypopharynx. The Nasopharyngeal Airway (NA) is a conical channel made up of muscles and mucosa, in addition to the presence of the adenoids, an intricate network of lymphatic tissues located in the posterior area. Predisposing elements, such as repeated infections or inflammation, often lead to enlargement of the adenoids and narrowing of the posterior airway in developing infants. As a result of the partial decrease in nasal respiratory function, children affected by reduced NA tend to resort to oral respiration [3].

Various investigations have evaluated the airways through two-dimensional cephalometric radiographs. However, these studies only establish linear measurements of sagittal or transverse aspects, which prevents accurate representation of the morphology of the airways or the areas that cause breathing disorders. Therefore, Cone Beam Computed Tomography (CBCT) is emerging as a reliable and effective technique to quantitatively assess the volume and cross-sectional areas of the airways. This three-dimensional imaging tool, coupled with a computer program capable of generating volumetric data and segmenting different areas of the airways, allows clinicians and scholars to analyze changes in the airway that affect the quality of breathing after orthodontic and orthognathic treatments [10].

Cephalograms produce two-dimensional images with magnification, distortion and superimposition of adjacent structures. CBCT is an ideal diagnostic aid to study the airway in all three dimensions [11].

However, lateral skull teleradiography is a standardized and widely available radiographic technique commonly used in orthodontics to study craniofacial structures. To check for changes in craniofacial and dentofacial structures, teleradiography is performed before and after mandibular advancement, and a cephalometric analysis is traced to check for increased airway parameters. The increase in airway dimensions seems to have an important effect on the success of mandibular advancement and, therefore, the comparative analysis of the craniofacial structures is one of the possible ways to evaluate the effect of this therapy [12-14].

Thus, the objective of this research is to verify and verify the efficacy of mandibular advancement appliances in the treatment of Class II malocclusions with mandibular retrognathism in growing patients and thus to extrapolate it also to patients with pediatric OSAS, defining a cephalometric method of routine and simple use, for the diagnosis and treatment of this. Establishing as hypothesis of the research that there are no statistically significant differences between airway measurements before and after mandibular advancement treatment in growing Class II patients with mandibular retrognathism.

## Materials and Methods

The study was accepted by the ethics committee and all patients signed the informed consent form. Thus, Organic Law 15/1999, of December 13, 1999, on the Protection of Personal Data was respected at all times by coding the patients by consecutive numbers according to the order of access to the study.

### Participants

Children and adolescents between 8 and 15 years old diagnosed with a mandibular Class

II malocclusion, who are patients of the Master of Advanced Multidisciplinary Orthodontics (MOMA) of the San Pablo CEU University of Madrid and have been treated in a first phase, with a mandibular advancement appliance 6 months ago or less. A total of 26 patients following the inclusion and exclusion criteria, from which the data is obtained, has begun in 2019, and with the period of the COVID pandemic and post- pandemic. This is a pilot study, with the patients currently available in the Master's program, not for convenience, but with the existing patients.

### Study Design

Once the radiographs of the 30 patients in the study group who had undergone mandibular advancement with orthopedic appliances had been selected, the analysis of the lateral teleradiographs of the skull was performed using the Nemoceph program, establishing the reference points in each of the radiographs in the study, and the measurements were plotted and estimated using the Nemoceph program, using the Arnett analysis of the pharyngeal airways.

Following the linear measurements of the air space proposed by the Arnett/Gunson FAB (Face Airway Bite) surgery cephalometric analysis, four craniometric points are measured: A, MCI, B, Pg:

- Posterior Airway Space (SPAS) at point A (SPAS at A): a line is drawn perpendicular to the true vertical line passing through point A and extending posteriorly, intersecting the anterior (A/G SPAS anterior at A) and posterior (A/G SPAS posterior at A) boundaries of the posterior upper airway space.
- SPAS at point MCI (SPAS at MCI): A line is drawn perpendicular to the true vertical line passing through point MCI (point located at the incisal edge of the maxillary central incisor) and extending posteriorly, intersecting the anterior (A/G SPAS anterior at MCI) and posterior (A/G SPAS posterior at MCI) boundaries of the posterior upper airway.

- SPAS at point B (SPAS at B): A line is drawn perpendicular to the true vertical line passing through point B and extending posteriorly, intersecting the anterior (A/G anterior SPAS at B) and posterior (A/G posterior SPAS at B) boundaries of the upper posterior airway space.
- SPAS at point Pog (SPAS at Pg): A line is drawn perpendicular to the true vertical line passing through point Pg at the anterior (A/G anterior SPAS at Pg) and posterior (A/G posterior SPAS at Pg) wall of the posterior upper airway (Table 1).

| | **Centralidad** | | **Variabilidad** | | |
|---|---|---|---|---|---|
| Variable | Media (IC 95%) | Mediana | Min. / Máx. | D.S. | R.IQ. |
| Pre-Tto SPAS en A | 16.72 (15.18 – 18.26) | 17.02 | 5.78 / 23.88 | 3.81 | 4.72 |
| SPAS en MCI | 11.82 (10.43 – 13.21) | 11.87 | 6.01 / 20.28 | 3.44 | 3.9 |
| SPAS en B | 11.17 (10.02 – 12.33) | 10.84 | 6.94 / 17.91 | 2.85 | 3.38 |
| SPAS en Pg | 12.43 (10.97 – 13.89) | 12.4 | 7.65 / 21.15 | 3.61 | 5.51 |
| Post-Tto SPAS en A | 17.68 (16.25 – 19.12) | 17.35 | 11.41 / 24.44 | 3.55 | 5.4 |
| SPAS en MCI | 13.90 )12.40 – 15.40) | 13.25 | 8.29 / 22.49 | 3.72 | 5.8 |
| SPAS en B | 11.65 (10.19 – 13.10) | 10.61 | 6.18 / 17.63 | 3.61 | 5.79 |
| SPAS en Pg | 14.48 (12.89 – 16.07) | 15.06 | 8.38 / 22.11 | 3.93 | 7.24 |
| D.S. = Desviación estándar // R.IQ. = Rango Intercuartil | | | | | |

**Table 1:** Descriptive analysis of SPAS variables, in Pre and Post Treatment.

## Statistical Analysis

Statistical analysis was carried out using the IBM-SPSS Statistics version 25 software application. For the contrast of the significance of the means of the same sample of subjects, the parametric Student MR test was used. For the contrast between means of different groups of subjects, the parametric Student's test was used: Student's. The effect size was calculated to express the magnitude of the differences between samples. The Chi-square test of independence was used for the crossover between two categorical variables. In all these inferential statistical tests, significance is considered when p<.05 and high significance when p<.01.

## Results

After these initial analyses, the significance of the changes in the 4 SPAS variables between post and pre. These results are summarized in Table 5 and it follows that:

In the SPAS at point A, an increase of 0.96 mm was found, which is very close to statistical significance (p<.10). On the other hand, in SPAS at MCI we already found a difference, +2.07 mm, which is highly significant (with p<.01) and is accompanied by a very large effect size (29.2%). On the other hand, in SPAS in B, the increase is much smaller (barely 0.47 mm) which does not reach statistical significance (p>.05) and also corresponds to a small effect (barely 2.9%). Finally, in SPAS in Pog again there is a difference of +2.05 mm, which is highly significant (p<.01) with an effect size of 24.8%, which is close to being very large (Table 2).

| Media (±DS) Test de contraste Tamaño | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Diferencia** | | | | | | | |
| **entre** (Student MR del **IC (95%) de la** | | | | | | | |
| **Medidas Medidas** efecto **Diferencia** | | | | | | | |
| **Medias** | | | | | | | |
| **Variables** | **POST-Tto** | **PRE-Tto** | | **Estadístico** | **P-valor** | **R2** | |
| **SPAS en A** | 17.68 (±3.55) | 16.72 (±3.81) | 0.96 | 1.42 (¥) | **0.084** | **0.075** | ---- |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **SPAS en MCI** | 13.90 (±3.72) | 11.82 (±3.44) | 2.07 | 3.21 (**) | **0.002** | **0.292** | 0.74 – 3.40 |
| **SPAS en B** | 11.65 (±3.61) | 11.17 (±2.86) | 0.47 | 0.86 (NS) | 0.198 | 0.029 | ---- |
| **SPAS en Pg** | 14.48 (±3.93) | 12.43 (±3.61) | 2.05 | 2.87 (**) | **0.004** | **0.248** | 0.58 – 3.52 |
| (NS)= NO significativo | (¥) = Casi significativo | (**) = Altamente significativo | | | | | |

**Table 2:** Analysis of the change in SPAS variables between Post and Pre-Treatment.

After the previous analyses, we proceeded to study whether these observed changes are more associated with one type of device or another. To this end, 4 arithmetic difference variables were generated, resulting from subtracting the post-treatment and pre-treatment values for each participating subject.

First, we compared these group means of change according to whether their apparatus was HBO or twin Boques. As can be seen in it, although there are differences between both groups (with values between 0.04 mm and 0.92 mm, in absolute terms), none of them reach statistical significance (p>.05). Along the same lines, the effect size values are small (<2%) or even practically null (<1%). Therefore, there is no statistical evidence that the type of device used in the treatment is a determining factor in the change in SPAS being of greater or lesser magnitude (Table 3).

| Media (±DS) | | | | Test de contraste (Student) | | Tamaño del efecto **R2** |
|---|---|---|---|---|---|---|
| | **Bloques gemelos** | **HBO** | **Diferencia entre grupos** | | | |
| **Variables del CAMBIO** | (n=16) | (n=10) | | **Estadístico** | **P-valor** | |
| **Diferencia en SPAS en A** | 1.20 (±4.15) | 0.58 (±2.00) | / 0.62 / | 0.44 (NS) | 0.665 | *0.008* |
| **Diferencia en SPAS en MCI** | 1.72 (±2.82) | 2.64 (±4.04) | / 0.92 / | 0.69 (NS) | 0.499 | *0.019* |
| **Diferencia en SPAS en B** | 0.39 (±2.60) | 0.60 (±3.19) | / 0.20 / | 0.18 (NS) | 0.862 | *0.001* |
| **Diferencia en SPAS en Pg** | 2.03 (±3.62) | 2.07 (±3.87) | / 0.04 / | 0.02 (NS) | 0.98 | *0* |
| (NS)= NO significativo | | | | | | |

**Table 3:** Variables of change (Post-Pre-Difference) in SPAS, depending on the type of device.

The same analysis was then performed comparing the devices by mobility or not. The results also failed to detect statistically significant differences (p>.05) or significant effect sizes. Thus, there is no statistical evidence that mobility is, in general, a factor influencing changes in SPAS after the treatments. However, we can comment that in the variables of the change in SPAS in Pg, a moderate-high effect size (9.3%) is observed, which could be an indication of a possible difference between the groups (Removable: 3.32 vs Fixed: 1.11 mm) that is not significant due to the lack of a sufficient N for this (Table 4).

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Cementado** | **Removible** | **Diferencia entre grupos** | | | |
| Variables del CAMBIO | (n=15) | (n=11) | | Estadístico | P-valor | |
| Diferencia en SPAS en A | 0.64 (±3.49) | 1.40 (±3.50) | / 0.76 / | 0.55 (NS) | 0.587 | 0.012 |
| Diferencia en SPAS en MCI | 2.55 (±3.62) | 1.43 (±2.81) | / 1.12 / | 0.86 (NS) | 0.4 | 0.03 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Diferencia en SPAS en B | 0.26 (±2.72) | 0.76 (±2.97) | / 0.50 / | 0.44 (NS) | 0.662 | 0.008 |
| Diferencia en SPAS en Pog | 1.11 (±3.66) | 3.32 (±3.35) | / 2.21 / | 1.57 (NS) | 0.129 | 0.093 |

(NS)= NO significativo

**Table 4:** Variables of change (Post-Pre-Difference) in SPAS, as a function of device mobility.

**Discussion**

In the present investigation, the duration of treatment always ranges between 9 and 10 months, being the effective time to assess changes after mandibular advancement in growing patients with orthopedic appliances, improving Class II skeletal malocclusion of mandibular cause and subsequently assess a second phase. orthodontic treatment if necessary [8,15] The average age of the patients ranges around 10-12 years, coinciding with the pubertal peak, being the ideal age for the treatment of growing Class II patients who need mandibular advancement [6,7,16], despite Since there are more girls than boys included in the study, since the sample size is small, precise results cannot be obtained in terms of variability in gender, and since there is little variability in age, the same is true. Even so, the results obtained do not reach statistical significance due to the small sample size, but they reflect more change in men than in women, and at older age, more change in permeability, coinciding with the pubertal peak, being possible that it is a of the explanations for the increase in this effect.

In most of the studies according to Bidjan et al. 2020, it was shown that removable functional appliances exerted greater changes in the dimensions of the upper airways than fixed appliances in most of the variables analyzed, as in the current study. This could be due to the different skeletal/dentoalveolar effects of removable/fixed appliances that have been previously described. On the other hand, this could be due to the fact that fixed functional appliances are usually placed in early-aged patients before most of the primary teeth have come off, in 1st or 2nd phase mixed dentition, while removable functional appliances are usually placed in the young permanent dentition, coinciding with the pubertal peak. Furthermore, it is generally believed that the skeletal effects of functional appliances are more pronounced in patients treated before or during peak growth, as mentioned above. However, it remains to be seen whether these benefits remain stable in the long term [2].

Regarding the type of appliance used in the treatment of class II malocclusion with mandibular retrognathism in growing patients for mandibular advancement, the most used appliances were the HB and the BG, among which the use of the Twin-Block stands out (TB) versus the Klammt or the Bionator. The various systematic reviews and meta- analyses analyzed [1,3,17-19] do not reflect which appliance has the greatest effect on improving airway patency after mandibular advancement; they only reflect that Removable appliances have a greater effect than fixed ones, specifying that in other studies the HB is fixed, and the TB is removable, therefore, the HB is more effective and precise than the TB. In this research, both types of appliances can be both fixed and removable and can be cemented or not. As a result, there are no statistically significant differences due to the sample size, but it does reflect slightly greater effectiveness in the use of HB, and mostly if it is removable.

Finally, regarding the results obtained in airway patency, mandibular advancement with removable or fixed functional appliances was associated with statistically significant increases in the dimensions of the airways directly after treatment, although there is no control sample to corroborate which would be expected to modify the airways solely due to the growth of Class II alone, as in Oliveira et al 2020 [20].

In the present study, more changes were observed in the volume of the NA, followed by the laryngopharynx than in the oropharynx, presenting a notable increase in air permeability at points A, MCI and very prominent at Pg, unlike point B. which reflected minor changes. This does not agree with the other studies analyzed such as that of Ferraz et al. 2022 and Bariana et al. 2022 [12,21], in which many of these changes were noted especially in the upper pharynx, and were of small to moderate magnitude, meaning that changes in the nasopharynx could have little clinical relevance. In contrast, greater effects were observed in the lower pharynx, indicating that any clinically relevant benefits in airway dimensions or breathing could be attributed to this compartment, consistent with the results of the present study.

According to Do Vale et al. 2019, an explanation for the improvement of the airway at point Pg and less at point B, is due to the rotation of the occlusal plane counter clockwise, described as a movement that optimizes the gain of space in the airways. Respiratory [12,22].

The changes observed notably at craniometric point A can be explained not by the use of the advancement apparatus itself, since its effects would be noticeably more indicated at points B and Pg, but because, being mostly patients at the peak of growth, the maxilla continues to grow, with the exception of the mandible, which is the one that presents the skeletal problem and we favor its increase with mandibular advancement.

### Conclusions

There is a marked improvement in airway patency after treatment with functional mandibular advancement appliances in growing patients with Class II malocclusion with mandibular retrognathism.

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