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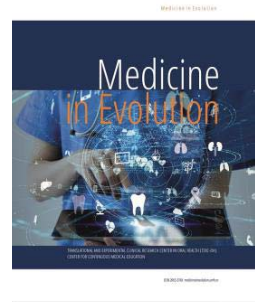
Impact of Skeletal Class II Malocclusions with Different Vertical Growth Patterns on the Upper Airway



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Abstract

1.Background/Objectives: Considering the clinical relevance of malocclusion in dentistry, the main objective of this study is to assess the changes in the upper airway dimensions in patients with skeletal Class II and a normodivergent growth pattern compared with those with skeletal Class II and a hyperdivergent growth pattern.2.Methods: This observational comparative study was conducted on lateral cephalograms and cephalometric analyses of 52 subjects obtained at the Dentavis imaging center in Timişoara. The sample was divided into two groups of n=25 and n=27 subjects, respectively: Group 1 included subjects with skeletal Class II malocclusion and a normodivergent growth pattern, whereas Group 2 comprised subjects with skeletal Class II malocclusion and a hyperdivergent growth pattern. 3.Results: In Group 2, the mean length of the upper pharyngeal airway was 3.68 mm smaller than the corresponding mean value in Group 1 ($p<0.001$), indicating that subjects with skeletal Class II and a hyperdivergent vertical growth pattern present a significantly more constricted upper pharyngeal airway compared with those with skeletal Class II and a normodivergent pattern. 4.Conclusion: Initiating orthodontic treatment would modify the cephalometric measurements and mandibular rotation, leading to an increase in upper airway dimensions and an improvement in respiratory function.

Keywords: Upper pharyngeal airways, class II malocclusions, vertical growth pattern

INTRODUCTION

The World Health Organization (WHO) regards malocclusion as one of the most important oral health problems, after dental caries and periodontal disease. Its prevalence is highly variable and has been estimated to range between 39% and 93% in children and adolescents, with a wide and heterogeneous distribution that may be explained by ethnic and age-related differences among the populations included in epidemiological studies on malocclusion [1].

In Class II malocclusion, there is an anteroposterior discrepancy between the position of the teeth in the maxillary arch and those in the mandibular arch, which may or may not be associated with an underlying skeletal discrepancy. For orthodontists, this represents one of the most frequently encountered malocclusions in daily clinical practice. Skeletal Class II may result from excessive maxillary growth, deficient mandibular growth, or a combination of both. In such malocclusions, both the upper and lower airways can be affected. Typical features include a narrow maxillary arch, proclination of the upper anterior teeth and the development of oral breathing as a habitual pattern. Moreover, condylar position in skeletal Class II plays a key role in the onset of temporomandibular joint disorders [2].

This malocclusion has a multifactorial etiology and may be caused by hereditary factors, environmental influences, or a combination of the two. Genetically determined factors act during growth and may lead to the development of malocclusion, often in association with etiological factors such as detrimental oral habits: thumb, lip or cheek sucking, tongue interposition between the dental arches, and mouth breathing. If left untreated, persistent malocclusion can seriously affect patients' quality of life, leading to aesthetic, masticatory and phonatory problems that may be more or less evident depending on the severity of the condition. [3].

The assessment of the upper airway has always been of interest in orthodontics, with the main purpose of clarifying the relationship between pharyngeal structures and craniofacial growth and development [4]. The growth and function of the nasal cavities are closely related to normal cranial growth, while morphologic, physiologic or pathologic obstructive processes are recognized risk factors for upper airway obstruction; when present, they may induce a mouth-breathing pattern that alters facial morphology and dental arch form, ultimately leading to malocclusion. Consequently, such obstructive processes can simultaneously result in Class II malocclusion associated with oral breathing and narrowing of the upper airway if left untreated.

Specialist literature has reported a relationship between Class II malocclusions and mouth breathing, as well as an association between vertical growth pattern and airway obstruction. Thus, patients with Class II occlusions and a hyperdivergent growth pattern may present narrower airways than those with a normodivergent pattern or with Class I occlusion. In Class II malocclusions without evident pharyngeal pathology, the nasopharyngeal space has been shown to be vertically narrower than in subjects with a normal growth pattern, and in Class II patients with vertical growth patterns, the nasopharynx is substantially narrower than in Class II patients with normal growth. De Freitas et al. reported that upper pharyngeal width was significantly smaller in individuals with Class I and Class II malocclusions and vertical growth patterns than in those with normal growth [6]. Wang et al. found a reduced airway space in adults with high-angle skeletal Class II, confirming the association between pharyngeal airway space and a vertical skeletal pattern, and suggesting that a vertical growth pattern may predispose individuals to pharyngeal narrowing and potential upper airway obstruction. [7,8]. Ponnada et al. also demonstrated that linear and angular nasopharyngeal measurements were smaller in Class II subjects with a hyperdivergent growth pattern compared with Class I subjects with an average growth pattern. [9].

Aim and objectives

Given the clinical importance of malocclusion in dentistry, the main objective of the present study is to evaluate changes in the upper airway dimensions in patients with skeletal Class II and a normodivergent growth pattern compared with those with skeletal Class II and a hyperdivergent growth pattern.

MATERIAL AND METHODS

The observational comparative study was conducted on 52 lateral cephalograms and corresponding cephalometric analyses obtained at the Dentavis imaging center in Timișoara, in order to ensure the highest possible accuracy of the results. All subjects in both groups had their cephalograms taken under standardized conditions, and participation was authorized by informed consent, which was signed by the patients and their legal guardians.

The sample consisted of 52 untreated subjects (27 females and 25 males) diagnosed with skeletal Class II malocclusion, aged between 13 and 17 years, with a mean age of 14.75 ± 1.16 years.

For the inclusion criteria in the study, subjects had to present no pharyngeal pathology and no clinical signs, symptoms or suspicion of nasal obstruction. Exclusion criteria were horizontal (hypodivergent) growth pattern and the presence of Class I or Class III malocclusions.

The sample was divided into two groups of n=25 and n=27 subjects, respectively. Group 1 consisted of subjects with skeletal Class II malocclusion and a normodivergent growth pattern, whereas Group 2 included subjects with skeletal Class II malocclusion and a hyperdivergent growth pattern; all subjects in both groups presented Class II molar relationship.

For each lateral cephalogram, a comprehensive cephalometric report was generated, including several established analyses designed to define normative standards for facial proportions. At the Dentavis radiology center in Timișoara, a complete cephalometric analysis was produced individually for every patient, and all measurements were performed digitally using the CephX software.

The growth pattern was classified on the basis of the cephalograms. The following angular measurements were used to distinguish normodivergent from hyperdivergent skeletal patterns: FMA, the angle between the Frankfurt horizontal plane and the mandibular plane; SN-GoGn, the angle between the cranial base plane (Sella–Nasion) and the mandibular plane (Gonion–Gnathion); and NS-Gn, the angle formed by the lines connecting Nasion, Sella and Gnathion, which reflects the vertical and anteroposterior growth of the mandible. The upper pharyngeal airway space was measured on the lateral cephalograms as the linear distance from the posterior contour of the soft palate to the nearest point on the posterior pharyngeal wall.

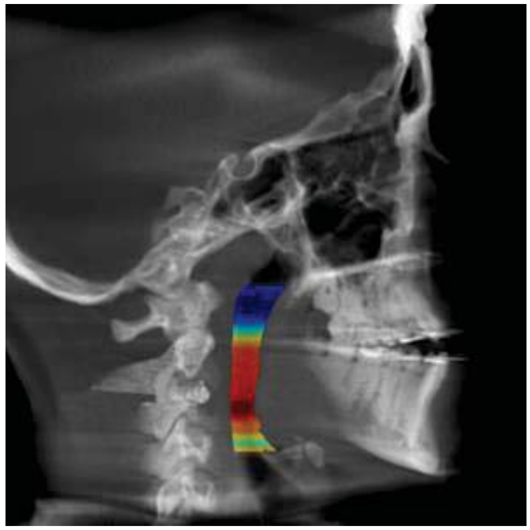

Figure 1. Airway width on lateral cephalograms

Microsoft Excel 2019 was used to calculate and graphically display the parameters of interest in this study. The results are presented as charts, tables and diagrams, and are expressed as absolute numbers or percentages, with the level of statistical significance set at $p<0.05$.

Two previously calibrated investigators performed the measurements to ensure accuracy. The subjects' lateral cephalograms were calibrated to the same scale and printed, and on each image a line was drawn from the posterior contour of the soft palate to the closest point on the posterior pharyngeal wall to represent the upper pharyngeal airway; this tracing was performed by the first investigator using a ruler and a 0.30 mm lead pencil and then checked by the second investigator to verify the accuracy of the anatomic contour identification and landmark placement.

RESULTS

All subjects were diagnosed with skeletal Class II malocclusion, with ANB angle values greater than 2°. The study sample included 52 subjects, of whom 25 (41.66%) were male and 27 (58.34%) were female ($p=0.414$, $\chi^2=0.66$) (Figure 2). The sample was divided into two groups: Group 1, comprising 41.66% of the subjects, with skeletal Class II malocclusion and a normodivergent growth pattern, and Group 2, comprising 58.34% of the subjects, with skeletal Class II malocclusion and a hyperdivergent growth pattern (Figure 3).

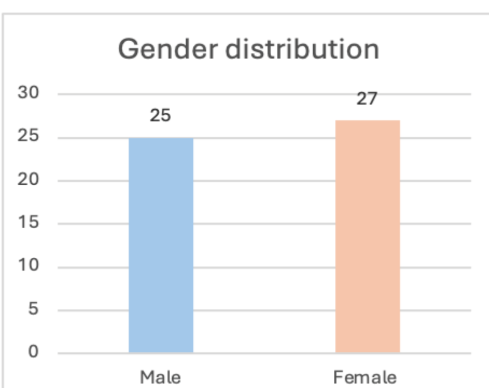

Figure 2. Distribution of the study sample by gender

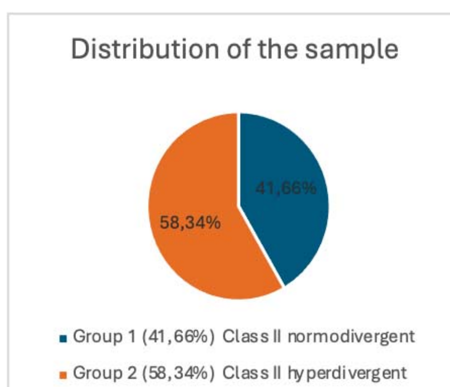

Figure 3. Distribution of the study sample by group

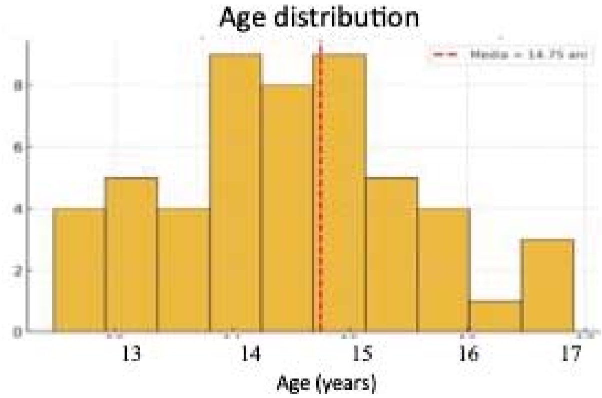

Figure 4. Age distribution of the study groups

The mean age of the total sample was 14.75 ± 1.16 years (Figure 4), with a minimum age of 13 years and a maximum age of 17 years. In Group 1, the mean age was 13.8 years, ranging from 13 to 15 years, with a median of 14 years, whereas in Group 2 the mean age was 15 years, ranging from 14 to 17 years, with a median of 15 years (Table I).

Table I. Statistical analysis of the study groups according to age

	Total group n=52	Group 1 n=25	Group 2 n=27
Minimum	13	13	14
Maximum	17	15	17
Mean	14,5	13,8	15
Standard deviation	1,16	0,83	1,15
Median	14	14	15

The subjects in Group 1 presented a mean ANB angle of 6.02°, whereas those in Group 2 had a mean ANB angle of 5. 81°.The three cephalometric variables measured on lateral cephalograms—FMA, SN-GoGn, and NS-Gn—were used to differentiate between normodivergent and hyperdivergent vertical growth patterns. FMA represents the angle between the Frankfurt horizontal plane (Po–Or) and the mandibular plane, reflecting the vertical skeletal pattern, with a normal value of 25° ± 3°. In the normodivergent group, all FMA values fall within the normal range, whereas among hyperdivergent subjects, only a small proportion show normal values, with most exceeding the upper limit of 28°.

The SN-GoGn angle represents the relationship between the mandibular plane and the cranial base, with a normal value of approximately 33°. In the normodivergent group, the values are close to this reference, with increases of up to about 4°. In contrast, the hyperdivergent group shows markedly elevated values, in some cases exceeding the normal limit by more than 9°.

NS-Gn is the angle formed by the lines connecting Nasion, Sella, and Gnathion, reflecting both the vertical and anteroposterior growth of the mandible; its normal value is around 67°. Subjects in the normodivergent group present values near this norm, whereas those in the hyperdivergent group display increases reaching 72–74°, exceeding the upper limit by more than 7°.

The values of the ANB angle—defined by points S, N, and A and used to reflect the sagittal position of the maxilla—are also presented. The normal ANB value is approximately 2°; increased values indicate a skeletal Class II pattern, whereas reduced or negative values suggest skeletal Class III. All patients in both groups show ANB values above 2°, confirming a skeletal Class II relationship, with mean values of 6.02° in Group 1 and 5.81° in Group 2.

In the lateral cephalograms of both groups, the upper pharyngeal airway was assessed as the linear distance between the posterior border of the soft palate and the nearest point on the posterior pharyngeal wall.

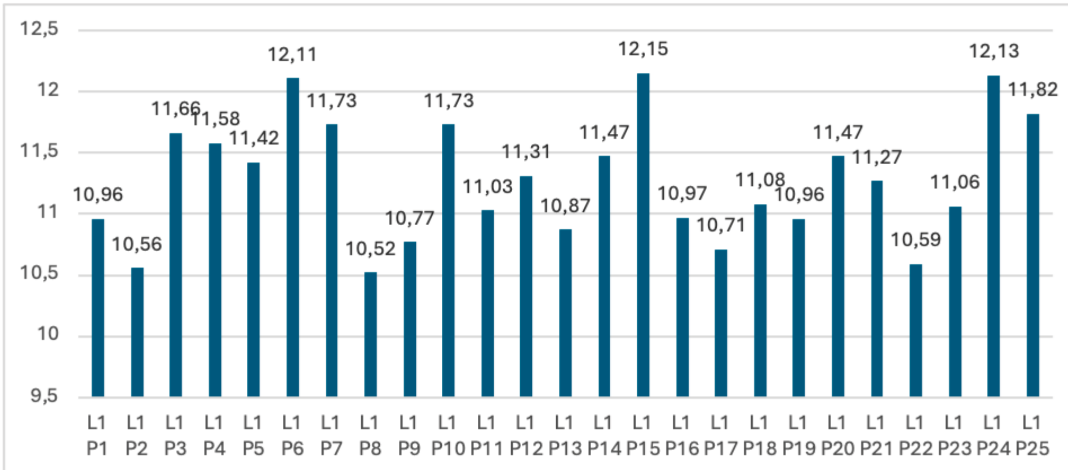

Figure 5. Upper pharyngeal airway measurement values for Group 1

The measurements showed that, in Group 1, the upper pharyngeal airway width ranged from a minimum of 10.50 mm to a maximum of 12.30 mm. The mean upper airway width in subjects with skeletal Class II and a normodivergent growth pattern was 11.28 ± 0.49 mm.

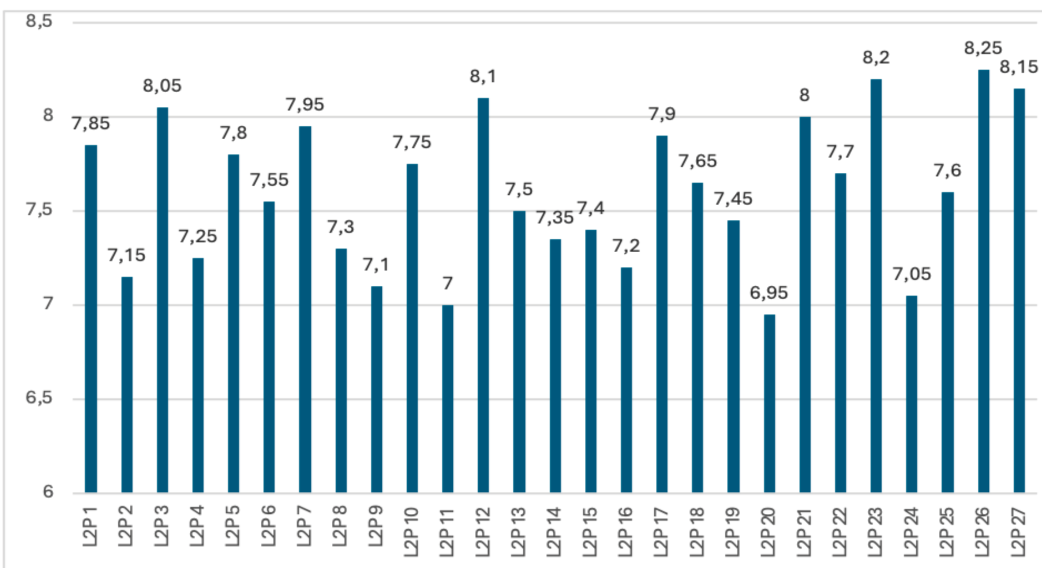

Figure 6. Upper pharyngeal airway measurement values for Group 2

In Group 2, comprising subjects with skeletal Class II and a hyperdivergent growth pattern, the mean upper pharyngeal airway width was 7.60 ± 0.40 mm, with a minimum value of 6.95 mm and a maximum value of 8.25 mm.

When comparing the groups, the mean length of the upper pharyngeal airway in Group 2 was 3.68 mm smaller than in Group 1 ($p<0.001$), indicating that subjects with skeletal Class II and a hyperdivergent growth pattern have significantly more constricted upper pharyngeal airways than those with skeletal Class II and a normodivergent growth pattern.

DISCUSSIONS

The selected lateral cephalograms belonged to subjects aged between 13 and 17 years, who already had a fully erupted permanent dentition but were still in the growth period. These patients had not received any orthodontic treatment with removable appliances during the mixed dentition phase. Some authors suggest that early intervention can reduce the severity of the anomaly or even prevent its occurrence. [10]. Early intervention may reduce the overall need for complex orthodontic treatment, such as permanent tooth extractions or orthognathic surgery. [11]. Furthermore, studies have shown a lower incidence of root resorption and ectopic eruptions when treatment is initiated during the mixed dentition stage. [12].

Although the number of subjects in each group may be considered relatively small, age and sex were well matched between groups. Owing to the retrospective design of the study, a direct assessment of each patient's nasal breathing pattern was not possible, so the selection criteria were based on information from the clinical records at the initial visits regarding pharyngeal pathology, clinical signs and symptoms, and complaints of nasal obstruction, any of which could have been related to adenoidal hypertrophy or enlarged tonsils [13]. The selected patients did not exhibit any of these factors and were therefore considered to have healthy pharyngeal function. This approach excluded patients with severe pathological pharyngeal obstruction, who would have shown some of the aforementioned signs and symptoms; however, it did not allow for the detection of mild or moderate pharyngeal obstructions. [14]. Nevertheless, because these selection criteria were applied to both groups, they were considered comparable. Consequently, since only relatively healthy pharyngeal patients with skeletal Class II malocclusion were included, the pharyngeal widths were expected to reflect solely their natural anatomic conditions, without pharyngeal pathology.

Subjects with Class II malocclusion and a vertical growth pattern presented significantly narrower upper pharyngeal airways than Class II subjects with a normodivergent growth pattern (Figure 5 and Figure 6), confirming previous findings reported in the literature. [15].

By analysing these results, it can be inferred that upper airway width is influenced by the craniofacial growth pattern, as previously suggested. However, some studies have reported weak correlations between growth pattern, facial morphology and nasopharyngeal airway dimensions, probably because they assessed the influence of the nasopharyngeal airway in conjunction with facial form and occlusion.

The present study was conducted on two dimensional radiographs to evaluate only the widths of the pharyngeal airways, not airflow capacity, which would require a more complex three dimensional and dynamic assessment; recent studies have indeed highlighted the value of three dimensional evaluation using magnetic resonance imaging [16] the high cost of this investigation and the lack of standardization of the patient's head position still limit the use of this method in research. According to Muto[17] a 10° change in craniofacial inclination can alter measurements in the upper airway region by approximately 4 mm. Lateral cephalograms were used for this type of assessment as part of the patients' orthodontic records, offering the advantages of low cost and low radiation dose, easy accessibility, and standardized measurements with high reproducibility for diagnostic purpose [18]. These advantages make this method widely used in research, which supports the methodology adopted in the present study and allows comparison of the results.

The findings do not indicate that subjects with a vertical growth pattern have a lower respiratory flow than those with a normodivergent growth pattern. However, Ricketts [20] și Dunn [21] they observed that nasal obstruction leading to mouth breathing is related to the width of the nasopharynx; the narrower the nasopharyngeal space, the less adenoidal enlargement is required to obstruct the nasopharyngeal airway. This helps explain the higher prevalence of mouth breathing in subjects with vertical growth patterns. Paul și Nanda [22] observed that higher prevalences of mouth breathing and nasopharyngeal airway obstruction have been reported in subjects with Class II malocclusions. The present study included only patients without evident pharyngeal pathology, whereas other investigations have used randomly selected subjects; some contrasting studies have compared nasal breathers with mouth breathers and found a higher proportion of mouth breathers among Class II patients, who consequently had a narrower nasopharynx.

Class II malocclusion can affect patients' daily lives both aesthetically and functionally. One of the most common functional problems is inadequate airflow through the nasal cavities, which leads patients to use the oral cavity to compensate for the impaired nasal function; unfortunately, mouth breathing is considered a detrimental habit associated with two major consequences: reduced cerebral oxygenation and sleep disturbances. Due to chronic under oxygenation, patients experience persistent fatigue and poor concentration, which makes everyday activities more difficult, and in addition they cannot rest properly because sleep is interrupted by apneic episodes and xerostomia related to mouth breathing.

On some lateral cephalograms, an accentuation of the cervical spine curvature can be observed, supporting the findings of Nobili and Adversi, who demonstrated that subjects with Class II malocclusion present a forward displaced posture. These patients tend to tilt the head anteriorly, resulting in greater head extension relative to the vertebral column and, consequently, a more pronounced lordotic curvature of the spine. [24].

This study showed that, in Class II malocclusions without evident pharyngeal pathology, the nasopharyngeal airway is narrower in subjects with a hyperdivergent vertical growth pattern than in those with a neutral growth pattern. However, the prevalence of pharyngeal obstruction across different growth patterns and malocclusions was not evaluated and should be addressed in future studies.

CONCLUSIONS

Vertical growth patterns in the subjects can be defined using at least three correlated cephalometric measurements (FMA, SN-GoGn, and NS-Gn), because the FMA angle alone is insufficient for categorization, as some subjects in Group 2 with a hyperdivergent pattern still showed normal FMA values. Patients with Class II malocclusions and a hyperdivergent vertical growth pattern have significantly narrower upper pharyngeal airways than Class II patients with a neutral growth pattern.

The narrowing of the upper airway is attributed to altered mandibular rotation and maxillo mandibular discrepancy, with the mandible being retruded in most cases. Changes in upper airway width do not depend on the sagittal subdivision of skeletal Class II, but rather on the vertical growth pattern. nitiating orthodontic treatment would modify the cephalometric measurements and mandibular rotation, leading to a reshaping of the upper airway and an improvement in respiratory function.

Conflicts of Interest

The authors declare no conflict of interest.

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