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The Relationship between Upper Airways and Orthodontic Treatment

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Abstract

Introduction: The aim of this study was to evaluate changes in maxillary sinus dimensions following orthodontic treatment across different malocclusion groups.

Materials and Methods: This retrospective study included 30 patients who met the inclusion criteria. Panoramic radiographs taken before and after orthodontic treatment were analyzed to assess maxillary sinus dimensions, which were then compared according to malocclusion classification.

Results: Significant differences were observed in the maxillary sinus base length, planar length, and area before and after treatment. In the Class I group, post-treatment measurements showed a decrease in sinus indentation base length, while planar length and sinus area increased. In the Class II group, both sinus indentation base length and planar length increased, but sinus area decreased. In the Class III group, indentation base length and planar length decreased, whereas sinus area increased following treatment ($p<0.05$ for all).

Discussion: Orthodontic treatment induces measurable changes in maxillary sinus dimensions that vary depending on malocclusion type. These findings highlight the importance of considering potential craniofacial changes before planning orthodontic therapy. Orthodontic treatment strategies should be designed with careful attention to the possible impact on sinus morphology to minimize complications.

Keywords: Maxillary sinus; Orthodontic treatment; Malocclusion groups; Panoramic radiographs

1. Introduction

The relationship between the maxillary sinus and dental root position has been a subject of investigation for centuries (1). Maxillary sinus dimensions serve as a functional indicator with direct implications for normal craniofacial development (2). Although previous studies report varying outcomes, the consensus is that tooth position influences sinus dimensions. The sinus enlarges progressively from the mixed dentition stage through to permanent dentition (3,4). Given their anatomical proximity, teeth and the maxillary sinus likely interact (5).

Several studies suggest that inadequate sinus dimensions may be associated with Class II molar relationships and increased anterior facial height (6). Furthermore, the possible link between respiratory function and craniofacial morphology has been discussed as a contributing factor in dentofacial anomalies (7). Other researchers argue that sinus dimensions may vary according to malocclusion type and tooth position (8).

Since much of the maxillary sinus lies within the craniofacial complex, orthodontists may evaluate its dimensions for diagnostic and treatment planning purposes. Identifying sinus deficiencies early allows for appropriate modification of orthodontic treatment strategies, thereby reducing the risk of potential complications. The present study aimed to

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investigate changes in maxillary sinus dimensions following orthodontic treatment across different malocclusion groups.

2. Materials and methods

This retrospective study included 30 patients who had undergone fixed orthodontic treatment. Patients were selected from archived records according to strict inclusion and exclusion criteria. Eligible patients were required to have panoramic radiographs, no maxillary sinus pathology, no congenital or acquired anomalies (e.g., cleft lip/palate, trauma), and no history of previous orthodontic treatment.

Participants were classified into three groups (n=10 per group) based on skeletal malocclusion: Class I, Class II, and Class III. Only normodivergent growth patterns were included. Classification criteria were as follows:

- Class I malocclusion: ANB angle between 0° and 4°.
- Class II malocclusion: Class II molar-canine relationship, convex profile, ANB > 4°, and normodivergent growth pattern.
- Class III malocclusion: Class III molar-canine relationship, concave or flat profile, ANB < 0°, and normodivergent growth pattern.

Normodivergence was defined by an SN/GoGn angle between 26° and 38°. Skeletal maturation was evaluated using hand-wrist radiographs, following the Greulich-Pyle atlas and Helm et al. criteria. Patients showing developmental acceleration or delay beyond ±2 years were excluded.

Maxillary sinus measurements were obtained from pre- and post-treatment panoramic radiographs. Parameters included sinus indentation base length, planar base length, and sinus area, measured at 5 mm above the apex of the first molar root. Right and left sinus values were averaged. Only high-quality radiographs, free of magnification errors, low contrast, or blurriness, and taken in natural head position, were included. Radiographs were calibrated to 1:1 scale using the X-ray machine software, and measurements were performed digitally with the ImageJ program (Wayne Rasband, NIH, Bethesda, MD).

2.1. Statistical Analysis

Data were analyzed using SPSS version 20.0 (SPSS Inc., Chicago, IL, USA). A significance level of $p < 0.05$ was adopted. Sample size was calculated with G*Power (version 3.0.10, Kiel, Germany), indicating a minimum of 10 patients per group (α=0.05, power=90%). Normality of data distribution was assessed with the Kolmogorov-Smirnov test. Descriptive statistics were expressed as mean ± standard deviation (SD). ANOVA was applied to compare maxillary sinus dimensions across malocclusion groups.

3. Results

When grouped by chronological age, the mean age of patients between 12–16 years was 14.1 ± 0.88 years, while for those aged 16–20 years it was 16.6 ± 0.73 years. The malocclusion groups consisted of 11 males and 19 females.

In the Class I group, post-treatment evaluation revealed a decrease in maxillary sinus indentation base length, accompanied by an increase in planar base length and sinus area ($p<0.05$).

In the Class II group, both indentation base length and planar base length increased, while sinus area decreased compared to pre-treatment values ($p<0.05$).

In the Class III group, indentation base length and planar base length decreased, whereas sinus area increased following treatment ($p<0.05$).

4. Discussion

The maxillary sinus represents a key component of the craniofacial complex and its dimensions are influenced by multiple factors (8,9). The hypothesis of this study was that orthodontic treatment would reduce sinus size in different malocclusion groups. Our findings demonstrated distinct dimensional changes depending on skeletal classification: a

reduction in indentation base length with enlargement of area in Class I, an opposite trend in Class II, and decreased base lengths but increased area in Class III.

Various imaging techniques have been employed in previous research to evaluate sinus dimensions. While cone-beam computed tomography (CBCT) offers superior three-dimensional accuracy, panoramic radiographs were used in this study due to lower radiation exposure, cost efficiency, and routine clinical applicability.

Sex-related differences in sinus dimensions have been reported inconsistently. Some studies found larger maxillary sinus and pharyngeal structures in males (8,10), while others, such as Daniel et al., reported no significant differences between sexes using MRI-based measurements (9). Conversely, cephalometric assessments by Mermut et al. indicated significant gender-related differences (8). CBCT studies have further shown that airway dimensions continue to expand until approximately age 15 in females and 18 in males, with a more pronounced increase in total airway volume observed in males from age 11 onward (10). Abramson et al., however, found no significant sex-related differences except in vertical airway length (9).

In designing this study, measurement protocols were chosen for both reproducibility and comparability with recent literature. The anteroposterior position of the mandible may influence the genioglossus muscle and tongue root position, predisposing individuals with posteriorly positioned mandibles to airway narrowing (10). Conversely, orthopedic advancement of the mandible has been associated with expansion of sinus dimensions and improved airway capacity (11).

Age also plays a role: as individuals mature, the maxillary sinus, tongue, and soft palate dimensions enlarge, while the hyoid bone tends to descend vertically. Generally, men present with larger sinus dimensions, greater tongue length, and wider sinus areas, whereas women show longer soft palate lengths. In this study, maximum sinus dimensions were noted in individuals with skeletal Class II malocclusion, whereas narrower dimensions were more characteristic of Class III cases.

5. Conclusion

Maxillary sinus dimensions vary according to skeletal malocclusion type, being broader in Class I–II patients and narrower in Class III patients. These findings underline the importance of considering sinus morphology during orthodontic diagnosis and treatment planning. Validation through studies with larger, well-classified patient groups is necessary to strengthen these conclusions.

Compliance with ethical standards

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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