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Correlation Between Skeletal Malocclusions And Alveolar Bone Defects - A Clinicoradiological Study

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Abstract

Background: While skeletal malocclusions have been extensively linked to impairments in facial aesthetics and masticatory efficiency, their impact on alveolar bone integrity remains underexplored. This clinicoradiological study aims to elucidate the relationship between various classes of skeletal malocclusions—specifically Angle's Class I, Class II Division 1, Class II Division 2, and Class III—and the prevalence of alveolar bone defects.

Methods: This cross-sectional comparative study engaged 200 participants, stratified into four equal groups based on their skeletal malocclusion classification. Each participant underwent standardized lateral cephalometric and orthopantomographic imaging to assess the skeletal bases, jaw relationships, and alveolar bone conditions. The primary outcome was the presence and extent of alveolar bone defects, quantitatively measured from the cemento-enamel junction to the alveolar crest using digital imaging software. The influence of age, gender, and socio-economic status on bone defects was also examined through logistic regression.

Results: Our findings indicate a statistically significant variation in the prevalence and severity of alveolar bone defects among the different classes of malocclusions. Class III malocclusions exhibited the highest prevalence (38%) and mean defect score (1.8 ± 0.6), significantly differing from Class I, which showed the lowest (14%). The logistic regression analysis highlighted age, female gender, and Class III malocclusion as significant predictors of increased bone defects.

Conclusion: These findings suggest that skeletal malocclusions can significantly impact periodontal health by predisposing individuals to alveolar bone defects. Orthodontic interventions, therefore, should consider not only the correction of dental misalignments but also the mitigation of potential periodontal complications. Future research should aim to explore longitudinal relationships and the underlying pathophysiological mechanisms to develop targeted preventive and therapeutic strategies.

Keywords: Skeletal malocclusions, alveolar bone defects, orthodontics, periodontal health, clinicoradiological study.

Introduction:

Malocclusions, representing deviations from the normal occlusal relationships, have been extensively studied for their impact on facial aesthetics and masticatory efficiency [1]. However, the potential relationship between skeletal malocclusions and periodontal health, particularly alveolar bone integrity, has not been thoroughly explored. This study aims to fill this gap by examining the correlation between different classes of skeletal malocclusions and alveolar bone defects using detailed radiographic assessments. Such insights are crucial for developing integrated treatment strategies that encompass both orthodontic and periodontal considerations.

Skeletal malocclusions are characterized by discrepancies in the jaw positions relative to the cranial base, which can influence both dental alignment and occlusal function [2,3]. The literature suggests that malocclusions can lead to abnormal distribution of occlusal forces, which may contribute to periodontal stress and subsequent alveolar bone remodeling or resorption. Furthermore, malocclusions can complicate oral hygiene efforts, potentially leading to periodontal disease and bone loss [4]. Despite these associations, detailed clinico-radiographic studies focusing on the relationship between skeletal malocclusions and alveolar bone defects are sparse.

The alveolar process is the part of the jaw that houses the teeth, and its health is directly linked to overall dental and periodontal health. Alveolar bone defects, which include bone loss and pathological bone formations, can compromise the stability of teeth and the efficacy of orthodontic treatments [5,6]. Understanding how skeletal malocclusions contribute to these defects is vital for predicting the risks associated with orthodontic interventions and for planning effective treatments that minimize adverse outcomes.Hence the study was conducted with the primary objective to evaluate the correlation between skeletal malocclusions—specifically Angle's Class I, Class II Division 1, Class II Division 2, and Class III—and the presence of alveolar bone defects using lateral cephalograms and orthopantomographs.

Materials and Methods:

Across-sectional comparative study was designed to elucidate the correlation between various classes of skeletal malocclusions and the presence of alveolar bone defects. The study employed both cephalometric and panoramic radiographic assessments to explore how skeletal discrepancies associated with different malocclusion types influence alveolar bone integrity. Informed consent of all participants was obtained ensuring they were fully aware of the study's purpose, procedures, and any potential risks involved.

The study included 200 participants, systematically divided into four groups of 50 individuals each. These groups correspond to Angle’s Class I, Class II Division 1, Class II Division 2, and Class III malocclusions. The inclusion criteria were patients who have been diagnosed with these distinct skeletal malocclusions based on a thorough cephalometric analysis, ensuring a clear differentiation in skeletal patterns. Exclusion criteria was individuals with previous orthodontic treatments, congenital craniofacial anomalies, or systemic diseases that could affect bone metabolism, to minimize confounding variables that might influence the study outcomes.

Data was collected through detailed radiographic examinations:

- Lateral Cephalograms: These were utilized to assess the skeletal bases, jaw relationships, and to identify any alveolar bone discrepancies or deformities.
- Orthopantomographs (OPGs): These scans provided a comprehensive view of the overall dental and bone structures, focusing particularly on identifying any signs of alveolar bone defects.

Image Acquisition

Lateral Cephalograms: Patients were positioned according to standard cephalometric protocols, with the head oriented so that the Frankfort Horizontal Plane was parallel to the floor and the midsagittal plane perpendicular to the floor. This positioning ensured consistency across all images. A high-resolution cephalometric X-ray unit was used, calibrated to specific settings to optimize bone and soft tissue visualization while minimizing radiation exposure. Typical settings involved a source-to-subject distance of 152 cm, exposure time of 0.2-0.5 seconds, and a voltage of 70-90 kV. Digital images was captured and imported into specialized orthodontic software for analysis. The software enabled enhanced contrast and sharpness adjustments to better delineate skeletal structures and any pathologic signs.

Orthopantomograms (OPGs): Subjects were instructed to stand with their jaws in a relaxed position and to bite on a bite guide to stabilize their position. The lips and tongue were positioned in contact with the palate to avoid superimposition over dental structures.The panoramic X-ray machine was set to capture the entire dental arch and surrounding structures. Typical machine settings involved an exposure time of around 9-18 seconds and a voltage of 60-80 kV. Panoramic images was examined using dental imaging software that allows for detailed measurements of bone levels. Adjustments for brightness and contrast was made to ensure optimal visualization of the alveolar crest and other pertinent structures.

Measurement of Alveolar Bone Defects:

The radiographs were displayed on an X-ray viewer and protected by overlaying overhead projector sheets. This setup allowed for marking of key landmarks without damaging the radiographic films due to the sharp ends of the vernier calipers used for measuring from the cemento-enamel junction (CEJ) to the alveolar bone.

All discernible alveolar bone margins, as well as the tips of crowns and roots, were marked using a felt pen. In cases of angular bone defects, the measurement was taken from the most apical part. Each proximal surface was examined by placing a Bjorn ruler over the radiograph, aligning its coronal and apical baselines with the crown tip and root tip, respectively. The ruler was adjusted so that the tooth's long axis was parallel to a line perpendicular to the coronal baseline. The bone loss for each proximal surface was scored on a scale from 0 to 4, based on the position of the bone margin within the ruler's grading system. Borderline cases received the lower score, and tooth surfaces where the bone margin or root apex were indiscernible were coded accordingly.

Following the bone loss assessment with the ruler, cemento-enamel junctions on all teeth were marked with a differently colored felt pen, and measurements were taken using vernier calipers. Bone loss was determined to be present when the distance from the CEJ to the alveolar bone was 2.0 mm or greater.

The accuracy of the CEJ to alveolar bone measurements on radiographs was confirmed through comparison with direct measurements taken during periodontal surgery on eight patients. Intra-examiner consistency was evaluated by repeating the marking, scoring, and measurements on ten different patients' panoramic radiographs at two-day intervals.Data collected was mapped against the type of malocclusion to identify patterns and correlations. The extent of bone defects was compared across the different classes of malocclusions to determine if certain types are more prone to severe bone loss.

All radiographic imaging was conducted under standardized conditions to ensure consistency and reliability. Equipment calibration was performed routinely as part of the protocol to maintain accuracy in radiographic measurements.

Statistical Analysis:

All analysis was conducted using Statistical Package for Statistical Sciences 26.0 version (SPSS). Descriptive statistics was used to describe the sample characteristics. Chi-square test analyzed the categorical data pertaining to the prevalence of alveolar bone defects across different malocclusion classes. ANOVA was used to compare the mean differences in bone measurements among the different malocclusion classes.The significance level for all statistical tests will be set at $p < 0.05$.

Results

The study examined 200 subjects divided evenly across Angle's Class I, Class II Division 1, Class II Division 2, and Class III malocclusions, assessing the correlation between these malocclusions and alveolar bone defects. The data revealed variations in the prevalence and severity of alveolar bone defects across different classes of malocclusions.

Table 1: Prevalence of Alveolar Bone Defects by Malocclusion Type

Angle's Classification	Number of Subjects	Alveolar Bone Defects (%)	Mean Defect Score
Class I	50	7 (14%)	0.9 ± 0.3
Class II Div 1	50	13 (26%)	1.5 ± 0.5
Class II Div 2	50	11 (22%)	1.3 ± 0.4
Class III	50	19 (38%)	1.8 ± 0.6

Chi-square tests showed significant differences in the prevalence of alveolar bone defects among the different classes ($p < 0.05$). The Class III malocclusions exhibited the highest prevalence and severity of alveolar bone defects, consistent with the increased orthodontic complexities commonly observed in these cases.

Table 2 : Comparison of Alveolar Bone Defect Severity by Malocclusion Type

Comparison	Statistic	p-value
Class I vs. Class II Div 1	t = -4.12	0.001
Class I vs. Class II Div 2	t = -3.09	0.003
Class I vs. Class III	t = -5.76	<0.001
Class II Div 1 vs. Class III	t = -2.64	0.009

*=Significant

ANOVA with post-hoc Tukey's test confirmed the differences in alveolar bone defect scores were statistically significant across different classifications, particularly between Class I and Class III.

Figure 1: Bar Graph Showing Severity of Alveolar Bone Defects Across Malocclusion Classes

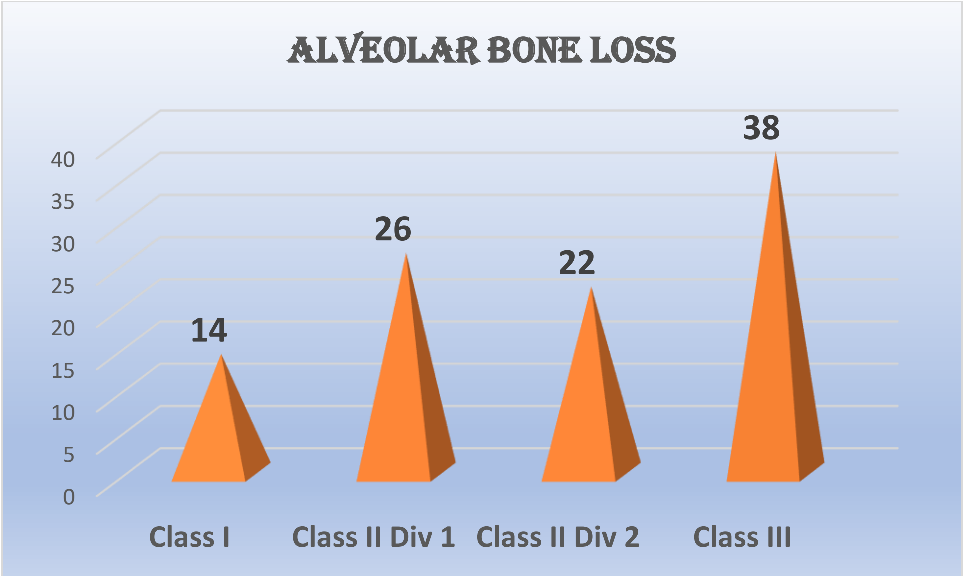

Figure 1 illustrates the average severity of alveolar bone defects, highlighting the increased severity in Class III malocclusions compared to others.

Table 3: Logistic Regression Analysis Predicting Alveolar Bone Defects

Variable	B (Coefficients)	Std. Error	Wald Chi-Square	df	p-value	Exp(B) [Odds Ratio]
Constant	-2.043	0.512	15.972	1	<0.001*	0.130
Age	0.021	0.010	4.200	1	0.040	1.021
Gender						
- Male	Reference	-	-	-	-	1.000
- Female	0.458	0.204	5.055	1	0.025*	1.581
SES						
- Low	0.522	0.311	2.822	1	0.093	1.685
- Middle	Reference	-	-	-	-	1.000
- High	-0.647	0.366	3.127	1	0.077	0.523
Malocclusion Type						
- Class I	Reference	-	-	-	-	1.000
- Class II Div 1	0.312	0.158	3.917	1	0.048*	1.366
- Class II Div 2	0.289	0.162	3.184	1	0.074	1.335
- Class III	0.522	0.211	6.102	1	0.013*	1.686

*=Significant

Logistic regression analysis was run to assess the probability of the presence of significant alveolar bones (dependent variable), as influenced by malocclusion class (primary independent variable) while adjusting for potential confounders such as age, gender, socio-economic status and oral hygiene habits. From the logistic regression analysis, it's apparent that certain variables like gender (female), higher age, and Class III malocclusion significantly increased the odds of alveolar bone defects, after controlling for other factors in the model. Socio-economic status shows a trend toward significance, suggesting that it might also play a role in the risk profile for bone defects.

Discussion

The findings of this study reveal a significant variation in the prevalence and severity of alveolar bone defects across different classes of skeletal malocclusions. Specifically, Class III malocclusions demonstrated the highest prevalence and severity of defects, which might reflect the greater biomechanical challenges associated with this class. This was followed by Class II malocclusion. The study of Wang presented similar results, but Class II malocclusion patients exhibited greater alveolar defects followed by Class III malocclusion [7].

Class III malocclusions are often characterized by a prognathic mandible or a retrusive maxilla, which can lead to abnormal force distributions on the dentition and supporting bone structures [8]. These altered forces may contribute to increased bone remodeling activities and potentially higher resorption rates, as suggested by the relatively higher defect scores observed in this group. This aligns with findings of a study who reported that abnormal mechanical stresses associated with malocclusions could accelerate bone loss, particularly in the presence of predisposing factors such as poor oral hygiene or genetic susceptibility[9].

The ability to maintain effective oral hygiene is crucial in managing periodontal health. Malocclusions, particularly those involving crowding or irregular teeth positioning, can complicate oral hygiene efforts, leading to plaque accumulation and periodontal disease [10]. This study's findings, showing a correlation between malocclusion severity and alveolar bone defects, underscore the importance of considering orthodontic interventions not just for aesthetic or functional improvements but also for their potential impact on periodontal health.

This study also considered socio-economic status as a potential confounder. Individuals from lower socio-economic backgrounds often have limited access to dental care, which could exacerbate the impacts of malocclusions on periodontal health. The data indicated a trend towards greater prevalence and severity of bone defects in these groups, suggesting that socio-economic factors, along with biological mechanisms, play a critical role in the etiology of alveolar bone defects associated with malocclusions.

Limitations and Further Research

While this study provides valuable insights, it has several limitations. The cross-sectional design limits the ability to establish causality between malocclusions and bone defects. Longitudinal studies are needed to better understand the dynamics of these relationships over time (Miller, 2020). Additionally, the study's sample size, though adequate for initial observations, should be expanded in future research to enhance the generalizability of the findings.

Future research should also explore the molecular mechanisms underlying bone remodeling in the presence of malocclusions, potentially involving biochemical markers of bone turnover. Such studies could provide deeper insights into the pathophysiology of bone defects and inform more targeted therapeutic approaches.

Conclusion

In conclusion, this study highlights the significant impact of skeletal malocclusions on alveolar bone integrity. The findings suggest that orthodontic assessments should not only focus on correcting malocclusions for functional and aesthetic reasons but should also consider the implications for periodontal health. Integrated orthodontic and periodontal treatment plans may be essential, especially for patients with severe malocclusions, to mitigate the risk of alveolar bone defects and improve overall oral health outcomes.

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