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Histological and Radiographic Analysis of the Alveolar Ridge in Partial Denture Users and Orthodontic Patients

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ABSTRACT

Objective: This study design was cross-sectional analytical. The objective was to compare the radiographic and histological characteristics of the alveolar ridge in partial denture users and orthodontic patients with congenitally missing teeth or those who require tooth extraction as part of their orthodontic treatment, focusing on ridge dimensions, bone density, and tissue health.

Methods: One hundred twenty participants were recruited at Rehman College of Dentistry from January 2022 to January 2024. Group 1 included 60 partial denture users, and Group 2 comprised 60 orthodontic patients with congenitally missing teeth or requiring tooth extraction as part of their orthodontic treatment. Radiographic evaluations were conducted using cone-beam computed tomography (CBCT) to assess ridge height, width, bone density, and resorption grades. Bone biopsies were analysed histologically to evaluate cortical thickness, trabecular density, inflammatory activity, and vascularisation. Statistical comparisons were performed using t-tests and chi-square tests, with a significance threshold of $p < 0.05$.

Results: Orthodontic patients exhibited significantly greater alveolar ridge height (10.5 ± 1.2 mm vs. 8.2 ± 1.5 mm, $p < 0.001$) and width (6.3 ± 0.9 mm vs. 4.5 ± 0.8 mm, $p < 0.001$) compared to denture users. Bone density was also higher in orthodontic patients (1025 ± 110 HU vs. 780 ± 120 HU, $p < 0.001$). Histologically, orthodontic patients showed thicker cortical bone (2.5 ± 0.4 mm vs. 1.8 ± 0.3 mm, $p < 0.001$) and higher trabecular density. Inflammatory markers and vascularisation were notably better in orthodontic patients. These findings highlight significant differences between the two groups' bone quality and ridge health.

Conclusion: Partial denture users experience more significant alveolar ridge resorption and compromised bone quality than orthodontic patients. Orthodontic treatment appears to preserve alveolar bone better, underscoring the need for early intervention and tailored treatment strategies. These results provide valuable insights for optimising clinical outcomes in patients with missing teeth.

Keywords: Alveolar ridge, partial denture, orthodontic treatment, bone density, ridge resorption, histological analysis, radiographic evaluation

INTRODUCTION

The alveolar ridge is a foundation for teeth and is vital in maintaining oral function, aesthetics, and overall dental health.¹ When teeth are lost, the ridge undergoes gradual resorption, which can result in significant structural and functional changes. These changes are especially pronounced in individuals who rely on partial dentures or undergo orthodontic treatments involving missing teeth.² Exploring the characteristics of the alveolar ridge in these populations is crucial for understanding the effects of tooth loss and treatment interventions on bone health³.

Partial denture users often experience progressive ridge resorption due to the mechanical stress exerted by the prosthesis and the lack of natural tooth stimulation⁴. This resorption impacts the fit and stability of dentures over time, leading to challenges in functionality and comfort. Additionally, systemic factors such as age, medical conditions, and lifestyle habits can exacerbate bone loss in denture users, compromising ridge integrity⁵.

Orthodontic patients with congenitally missing teeth or requiring tooth extraction as part of their orthodontic treatment face different challenges, as tooth movement and treatment-induced remodelling can alter alveolar ridge dimensions⁶. Maintaining bone quality in these patients is critical for achieving successful orthodontic outcomes, particularly in cases where future prosthetic rehabilitation is planned⁷. However, limited data exists comparing ridge preservation between orthodontic patients and denture users, highlighting the need for detailed investigations.

Radiographic techniques, such as cone-beam computed tomography (CBCT), provide valuable insights into alveolar ridge dimensions, including height, width, and bone density. These imaging modalities enable precise assessments of structural changes in the ridge over time. Complementing these analyses, histological studies offer a deeper understanding of the cellular and vascular factors influencing bone remodelling, including cortical bone thickness, trabecular density, and inflammatory activity⁸.

Understanding the interplay between anatomical and histological changes in the alveolar ridge is essential for improving treatment planning and outcomes in both groups. A comparative evaluation can identify differences in ridge health, aiding clinicians in selecting the most appropriate interventions to preserve bone integrity and functionality.

This study examines the radiographic and histological characteristics of the alveolar ridge in partial denture users and orthodontic patients with congenitally missing teeth or those who require tooth extraction as part of their orthodontic treatment. By analysing variables such as bone density, cortical thickness, and inflammatory markers, this research provides evidence-based insights to guide personalised treatment strategies for improving oral health and quality of life in these patient populations.

METHODOLOGY

This cross-sectional study was conducted at Rehman College of Dentistry over two years, from January 2022 to January 2024. The study aimed to compare the radiographic and histological characteristics of the alveolar ridge in partial denture users and orthodontic patients with congenitally missing teeth or requiring tooth extraction as part of their orthodontic treatment. Those patients were included who were referred for a biopsy and CBCT based on clinical indications over the past two years. The referrals were made by qualified healthcare professionals, including oral surgeons and orthodontists, who assessed the need for biopsy based on patient-specific clinical factors. All procedures involving human participants were conducted in accordance with the ethical standards and guidelines of the institutional review board. Informed consent was obtained from all participants before inclusion in the study, ensuring transparency and respect for patient autonomy. One hundred twenty participants were enrolled, with 60 individuals in each group. Group 1 included patients using partial dentures for at least six months, while Group 2 consisted of orthodontic patients with at least one missing tooth undergoing active treatment.

Participants were selected using predefined criteria. Inclusion criteria required individuals to be 18 years or older, in good general health, and free of severe systemic diseases that might influence bone health. Denture users had to wear partial dentures for a minimum of six months, while orthodontic patients had to be actively receiving treatment with documented cases of missing teeth. Patients with complete edentulism, long-term bisphosphonate therapy, or other medications affecting bone metabolism were excluded. Additionally, individuals with a smoking history exceeding ten years, active infections, or conditions affecting the alveolar ridge were omitted. Pregnant and lactating women were also excluded to avoid potential confounding variables.

The study adhered to ethical guidelines, obtaining approval from the Rehman College of Dentistry's ethical review board. After providing detailed information about the study objectives, procedures, and potential risks, written informed consent was obtained from all participants, ensuring their voluntary participation.

Comprehensive demographic and clinical data were also collected through structured interviews and questionnaires. Information on participants' age, gender, smoking habits, systemic conditions, duration of denture use, and orthodontic treatment was recorded. These variables provided context for the radiographic and histological findings, facilitating a thorough comparison between the groups.

Data collection included radiographic assessments, histological evaluations, and demographic data gathering. Radiographic measurements were performed using cone-beam computed tomography (CBCT), which provided high-resolution images of the alveolar ridge. Parameters such as ridge height, width, and bone density were measured. Residual ridge resorption was graded using a standardised four-tier classification system⁹. A trained radiologist performed all radiographic analyses to ensure consistency and minimize observer bias.

CBCT was utilized to evaluate the structural characteristics of the alveolar ridge in both groups. This imaging modality was selected for its superior precision and ability to provide detailed three-dimensional visualization of the alveolar ridge. CBCT assessments were performed for the following purposes:

- 1. Measurement of Ridge Dimensions**

- CBCT was used to measure ridge height (vertical dimension) and ridge width (horizontal dimension) at predetermined sites. These measurements allowed for an accurate comparison of ridge resorption between partial denture users and orthodontic patients.

- 2. Bone Density Assessment**

- Bone density was analyzed using Hounsfield units (HU) derived from CBCT scans. This provided quantitative data on the mineral content of the bone, enabling a comparison of bone quality between the two groups.

- 3. Residual Ridge Resorption Classification**

- A four-tier grading system was applied to CBCT scans to classify the extent of residual ridge resorption. This standardized approach ensured consistent and objective evaluation across all participants.

- 4. Identification of Pathologies**

- CBCT helped identify any underlying bone pathologies, dehiscence, fenestrations, or other abnormalities, ensuring that such conditions did not confound the study results.

- 5. Pre-Biopsy Planning**

- CBCT scans were used to identify the optimal site for bone biopsy collection, minimizing the risk to adjacent structures and ensuring the representativeness of the bone samples.

CBCT imaging was conducted for all participants by a trained radiologist using standardized protocols. The radiographic data were recorded and analyzed to ensure consistency and reliability. Bone biopsies were collected from all participants to complement the radiographic findings with histological analysis. For partial denture users (Group 1), bone biopsies were taken during minor surgical interventions, such as dental implant placements, commonly associated with this group. For orthodontic patients (Group 2), biopsies were collected during procedures like tooth extractions or surgical exposures, frequently part of orthodontic treatment plans. In both groups, a small cylindrical bone sample (approximately 2–3 mm in diameter) was obtained using a trephine bur under local anesthesia. While the trephine bur is the primary tool for bone biopsy collection, additional instruments like surgical drills, forceps, or curettes may be required to assist in the process. These tools ensure that the biopsy sample was retrieved intact and without unnecessary damage to the surrounding tissues. The following tools and techniques were utilized:

1. Trephine Bur:

- A trephine bur was used to create a cylindrical cut in the bone. It was attached to a low-speed surgical handpiece with continuous irrigation using sterile saline to prevent overheating and thermal damage to the bone.
- The bur effectively penetrated the cortical bone and collected a core sample containing both cortical and trabecular bone.

2. Bone Rongeur:

- After the initial cut with the trephine bur, a bone rongeur was used to carefully grasp and remove the bone core from the site. This ensured that the biopsy sample was retrieved intact without causing fragmentation.

3. Osteotome:

- For sites where the bone density was particularly high or when the bone core was tightly adhered, an osteotome was utilized to gently dislodge the sample. This instrument allowed for precise retrieval with minimal trauma to the surrounding tissues.

4. Surgical Curette:

- A surgical curette was used to clean the site and ensure all desired tissue was collected. This tool also helped retrieve any residual fragments left behind after the primary biopsy collection.

5. Hemostasis and Closure:

- Following the biopsy, the site was irrigated with sterile saline to remove debris and ensure proper visualization. Hemostasis was achieved using a resorbable hemostatic agent, a collagen sponge, if necessary. Depending on the clinical situation, the wound was closed with absorbable or non-absorbable sutures.

The procedure was performed under sterile conditions to prevent contamination and minimize discomfort. Care was taken to avoid damaging adjacent structures during sample collection.

After the bone biopsies were collected, they were processed similarly for both groups. The collected bone samples were immediately fixed in 10% neutral buffered formalin for 24–48 hours to preserve cellular structure. Decalcification was performed using 10% formic acid for a standardized duration to ensure proper softening of the bone for sectioning. The decalcified tissues were dehydrated through a graded alcohol series, cleared with xylene, and embedded in paraffin wax. Thin sections (4–5 µm) were cut using a microtome and mounted onto glass slides. Slides were stained with hematoxylin and eosin (H&E) to assess general bone structure, including cortical thickness, trabecular density, and inflammatory infiltration. H&E staining provided a clear view of the cellular architecture, allowing for the identification of inflammatory cells and structural changes.

To analyze specific inflammatory markers, immunohistochemistry (IHC) was performed on additional tissue sections. The process involved: Antibody Application: Primary antibodies targeting inflammatory cytokines, such as interleukin-1 beta (IL-1 β), tumor necrosis factor-alpha (TNF- α), and cyclooxygenase-2 (COX-2), were applied to the tissue sections. Detection: Secondary antibodies conjugated with chromogenic dyes were used to visualize the markers. Visualization: The presence and distribution of inflammatory markers were observed under a light microscope. Positive staining indicated areas of active inflammation. ELISA for Quantitative Analysis For precise quantification of inflammatory cytokines, an enzyme-linked immunosorbent assay (ELISA) was performed on homogenized bone tissue. The procedure included: Homogenizing a portion of the bone biopsy in a buffer solution (RIPA buffer) to extract proteins. Centrifugation to remove debris, followed by collection of the supernatant. Performing ELISA using commercial kits for IL-1 β , TNF- α , and IL-6 as per manufacturer instructions. Absorbance was measured using a microplate reader, and cytokine concentrations were calculated against a standard curve.

The prepared slides were stained with hematoxylin and eosin (H&E), which provides detailed visualization of bone structure, including cortical and trabecular components, as well as inflammatory cells and vascularization. H&E staining was chosen due to its ability to clearly differentiate bone architecture and cellular details, making it ideal for assessing the histological features of the alveolar ridge. The two independent pathologists evaluated the histological analysis of bone biopsy samples was performed using a light microscope equipped with adjustable magnification levels (10x, 40x, and 100x). This allowed for detailed visualization of the cortical and trabecular bone structures and cellular and vascular components of the tissue. Cortical bone thickness was assessed by examining the dense, compact regions of the bone. At the same time, the trabecular density was evaluated by observing the number, arrangement, and connectivity of trabeculae within the spongy bone. The presence of inflammatory cells, such as lymphocytes, macrophages, and neutrophils, was identified by their darkly stained nuclei, indicating areas of immune response or chronic inflammation. Blood vessels were visualized as circular or oval structures lined with endothelial cells, providing insights into the vascularization of the tissue.

To enhance the analysis, immunohistochemistry (IHC) was used to detect specific inflammatory markers such as interleukin-1 beta (IL-1 β), tumour necrosis factor-alpha (TNF- α), and cyclooxygenase-2 (COX-2). Chromogenic substrates applied during IHC staining resulted in visible colour changes, with positive markers appearing as brown or reddish staining, allowing precise localization of inflammation. Two independent pathologists reviewed all slides to ensure consistent interpretations and key regions were documented with digital images captured through a microscope-mounted camera. This comprehensive approach enabled a thorough evaluation of both structural and cellular changes in the alveolar ridge.

Any discrepancies in observations between the pathologists were resolved through discussion to ensure consistency.

In addition to histological analysis, radiographic assessments using cone-beam computed tomography (CBCT) measured ridge height, width, and bone density. Patient demographics, smoking status, medical history, and treatment duration were recorded through structured interviews and questionnaires.

Statistical analyses were performed using appropriate software (SPSS version 22) to ensure accuracy in data interpretation. Continuous variables, such as ridge height and bone density, were expressed as means and standard deviations. In contrast, categorical variables, such as residual ridge resorption grades, were presented as frequencies and percentages. Comparative analyses were conducted using t-tests for continuous variables and chi-square tests for categorical variables. A significance level of $p < 0.05$ was considered to identify meaningful differences between the groups.

Several measures were implemented to maintain data quality and reliability. One experienced radiologist conducted radiographic measurements, and two pathologists independently reviewed

histological evaluations. Double-checking of data entry and statistical analysis further ensured accuracy.

RESULT

The study population comprised 120 participants evenly divided between denture users and orthodontic patients. The mean age of denture users was significantly higher (45.2 ± 10.1 years) compared to orthodontic patients (30.4 ± 7.8 years, $p < 0.001$). This reflects the typical age distribution of denture users, who are older due to tooth loss often occurring later in life. Gender distribution was nearly identical in both groups, showing no significant difference ($p = 0.84$). A larger proportion of denture users were smokers (30.0%) compared to orthodontic patients (16.7%, $p = 0.04$), aligning with the understanding that smoking is a contributing factor to tooth loss. Similarly, systemic conditions like diabetes (20.0% vs. 8.3%, $p = 0.04$) and osteoporosis (13.3% vs. 3.3%, $p = 0.03$) were more prevalent in the denture user group, further emphasising the impact of health conditions on oral health.

Table 1: Demographic Characteristics of Study Participants

Variable	Categories	Group 1: Denture Users (n=60)	Group 2: Orthodontic Patients (n=60)	p-value
Age (Mean \pm SD)	-	45.2 ± 10.1	30.4 ± 7.8	<0.001***
Gender	Male	28 (46.7%)	27 (45.0%)	0.84
	Female	32 (53.3%)	33 (55.0%)	
Smoking Status	Smoker	18 (30.0%)	10 (16.7%)	0.04*
	Non-Smoker	32 (53.3%)	45 (75.0%)	
	Former Smoker	10 (16.7%)	5 (8.3%)	
Systemic Conditions	Diabetes	12 (20.0%)	5 (8.3%)	0.04*
	Osteoporosis	8 (13.3%)	2 (3.3%)	

A *** rating denotes a highly significant result, with a p-value of less than 0.001. A ** rating indicates a moderately significant result, with a p-value of less than 0.01. Finally, a * rating represents a statistically significant result, with a p-value of less than 0.05.

A significant difference was observed in the history of tooth extractions, with 83.3% of denture users having had extractions compared to only 33.3% of orthodontic patients ($p < 0.001$). This finding aligns with the higher reliance on prosthetics in denture users. In orthodontic patients, treatment duration varied, with the majority receiving 1–3 years of care. The types of appliances also differed, with brackets being more commonly used (85%) than aligners. These differences underscore the two groups' distinct treatment paths and dental histories.

Table 2: Dental History of Study Participants

Variable	Categories	Group 1: Denture Users (n=60)	Group 2: Orthodontic Patients (n=60)	p-value
Duration of Partial Denture Use	<1 year, 1–5 years, >5 years	40% / 30% / 30%	-	-
Type of Partial Denture	Removable, Fixed	55% / 45%	-	-
Previous Tooth Extractions	Yes / No	50 (83.3%) / 10 (16.7%)	20 (33.3%) / 40 (66.7%)	<0.001***

Orthodontic Treatment Duration	<1 year, 1–3 years, >3 years	-	10% / 50% / 40%	-
Type of Orthodontic Appliance	Brackets, Aligners	-	85% / 15%	-

Radiographic analysis revealed significant anatomical differences between the two groups. Denture users exhibited lower alveolar ridge height (8.2 ± 1.5 mm) and width (4.5 ± 0.8 mm) compared to orthodontic patients (10.5 ± 1.2 mm and 6.3 ± 0.9 mm, respectively; $p < 0.001$ for both). Denture users also significantly reduced bone density (780 ± 120 HU vs. 1025 ± 110 HU, $p < 0.001$), indicating advanced resorption and diminished structural integrity. Residual ridge resorption was more severe in denture users (mostly Grade II-III) than in orthodontic patients (mostly Grade I-II, $p = 0.002$). These findings highlight the pronounced anatomical impact of prolonged tooth loss and denture use.

Table 3: Radiographic Measurements of the Alveolar Ridge

Variable	Unit	Group 1: Denture Users (Mean \pm SD)	Group 2: Orthodontic Patients (Mean \pm SD)	p-value
Alveolar Ridge Height	mm	8.2 ± 1.5	10.5 ± 1.2	<0.001***
Alveolar Ridge Width	mm	4.5 ± 0.8	6.3 ± 0.9	<0.001***
Bone Density	Hounsfield Units (HU)	780 ± 120	1025 ± 110	<0.001***
Residual Ridge Resorption	Grade I-IV	Mostly II-III	Mostly I-II	0.002***
Pathologies	Yes / No	15 (25%) / 45 (75%)	5 (8.3%) / 55 (91.7%)	0.03*

Histological examination showed notable differences in bone quality and inflammatory activity. Cortical bone thickness was significantly lower in denture users (1.8 ± 0.3 mm) compared to orthodontic patients (2.5 ± 0.4 mm, $p < 0.001$). Trabecular bone density was predominantly low in denture users (60%), whereas orthodontic patients had higher proportions of medium (40%) and high density (50%, $p < 0.001$). Inflammatory cell counts were elevated in denture users (45 ± 8 cells/field) versus orthodontic patients (20 ± 6 cells/field, $p < 0.001$), suggesting a chronic inflammatory response likely due to denture wear. Additionally, vascularization was significantly reduced in denture users (10 ± 3 vessels/mm²) compared to orthodontic patients (18 ± 4 vessels/mm², $p < 0.001$). These findings underscore the histological deterioration associated with prolonged edentulism and prosthetic use.

Table 4: Histological Features of the Alveolar Ridge

Variable	Unit	Group 1: Denture Users (Mean \pm SD)	Group 2: Orthodontic Patients (Mean \pm SD)	p-value
Cortical Bone Thickness	mm	1.8 ± 0.3	2.5 ± 0.4	<0.001***
Trabecular Bone Density	Low, Medium, High	60% 30% 10%	10% 40% 50%	<0.001***
Inflammatory Cells	Count/Field	45 ± 8	20 ± 6	<0.001***
Vascularisation	Vessels/mm ²	10 ± 3	18 ± 4	<0.001***

Bone Turnover Markers	Low,	70%	15%	<0.001***
	Normal,	20%	35%	
	High	10%	50%	

Functional assessment revealed compromised outcomes in denture users. Occlusal forces were more uneven (50%) in denture users, whereas orthodontic patients displayed predominantly regular forces (60%, $p < 0.001$). The masticatory function was also less efficient in denture users (75% inefficient) compared to orthodontic patients (80% efficient, $p < 0.001$). Soft tissue thickness was significantly reduced in denture users (3.2 ± 0.5 mm) compared to orthodontic patients (4.5 ± 0.6 mm, $p < 0.001$), indicating tissue atrophy. The quality of keratinised tissue was poorer in denture users (60% poor) than in orthodontic patients (30% poor, $p < 0.001$), reflecting the structural challenges faced by denture users.

Table 5: Functional and Structural Variables

Variable	Categories/Unit	Group 1: Denture Users (n=60)	Group 2: Orthodontic Patients (n=60)	p-value
Occlusal Forces	Normal,	20%	60%	<0.001***
	High	30%	30%	
	Uneven	50%	10%	
Masticatory Function	Efficient,	25%	80%	<0.001***
	Inefficient	75%	20%	
Soft Tissue Thickness	mm	3.2 ± 0.5	4.5 ± 0.6	<0.001***
Keratinized Tissue Quality	Good,	40%	70%	<0.001***
	Poor	60%	30%	

When comparing groups, denture users showed significantly greater alveolar ridge resorption and reduced bone density than orthodontic patients and controls ($p < 0.001$). Inflammatory changes were prevalent in denture users but minimal or absent in orthodontic patients and controls ($p < 0.001$). Cortical bone thickness was also thinnest in denture users, moderate in orthodontic patients, and thickest in the control group ($p < 0.001$). These differences illustrate the cumulative effects of tooth loss and prosthetic wear on anatomical and structural parameters.

Table 6: Comparative Anatomical and Structural Findings

Variable	Group 1: Denture Users	Group 2: Orthodontic Patients	Control Group	p-value
Alveolar Ridge Resorption	Moderate	Mild	None	<0.001***
Bone Density	Reduced	Normal	Optimal	<0.001***
Inflammatory Changes	Present	Minimal	Absent	<0.001***
Cortical Thickness	Thin	Moderate	Thick	<0.001***

Patient satisfaction was significantly higher among orthodontic patients, with 70% reporting being highly satisfied, compared to only 40% of denture users ($p < 0.001$). Complications were more common in denture users, with 30% experiencing stomatitis and 20% reporting irritation. In contrast, orthodontic patients reported fewer complications (10% stomatitis, 15% irritation, $p < 0.001$). These results highlight denture users' functional and psychological challenges compared to orthodontic patients.

Table 7: Patient Satisfaction and Complications

Variable	Categories	Group 1: Denture Users (n=60)	Group 2: Orthodontic Patients (n=60)	p-value
Satisfaction Level	Highly Satisfied,	40%	70%	<0.001***
	Neutral, Dissatisfied	30%	20%	
		30%	10%	
Complications	Stomatitis, Irritation,	30%	10%	<0.001***
	None	20%	15%	
		50%	75%	

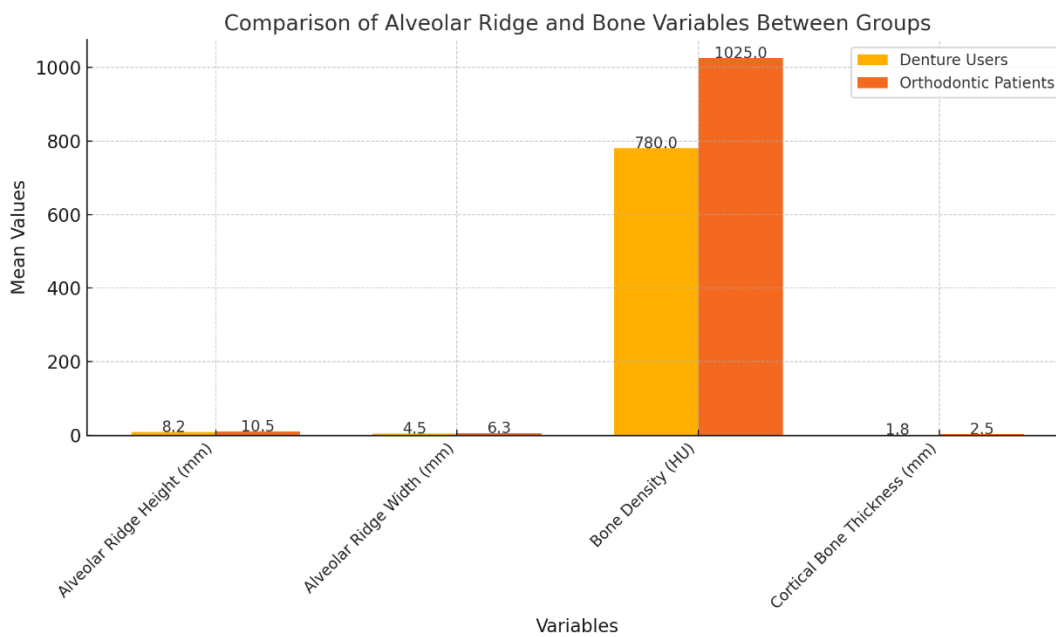


Figure 1: The graph highlights key differences between denture users and orthodontic patients in the alveolar ridge and bone characteristics. Orthodontic patients have significantly higher alveolar ridge height (10.5 mm vs. 8.2 mm) and width (6.3 mm vs. 4.5 mm), indicating better preservation of bone structure. Bone density is also greater in orthodontic patients (1025 HU vs. 780 HU), reflecting healthier bone quality. Additionally, cortical bone thickness is higher in orthodontic patients (2.5 mm vs. 1.8 mm), suggesting reduced bone resorption. These findings emphasise the impact of tooth loss and denture use on bone health and the advantages of orthodontic interventions in maintaining structural integrity.

DISCUSSION

This study compared the radiographic and histological characteristics of the alveolar ridge in partial denture users and orthodontic patients with congenitally missing teeth or those who require tooth extraction as part of their orthodontic treatment. The findings demonstrated significant differences in ridge height, width, bone density, and histological parameters between the two groups, highlighting the distinct effects of prosthetic and orthodontic interventions on alveolar bone health. These results align with previous research and provide essential insights into the clinical management of patients with missing teeth.

Compared to orthodontic patients, the reduced ridge height and width observed in partial denture users corroborate findings from earlier studies documenting the resorptive effects of edentulism and denture use. According to studies, the absence of natural tooth stimulation leads to progressive bone resorption,

exacerbated by the mechanical stresses imposed by prostheses^{10 11}. This study's findings were consistent with such observations, as denture users exhibited significant ridge dimensions 11-13 reductions. By contrast, orthodontic patients showed relatively preserved ridge height and width, likely due to adjacent teeth and ongoing bone remodelling stimulated by orthodontic forces.

Bone density was significantly lower in partial denture users compared to orthodontic patients. This finding aligns with studies emphasising that long-term edentulism leads to decreased bone quality and density, increasing the risk of prosthetic instability^{12 13}. Orthodontic patients in this study exhibited higher bone density, which may be attributed to the preservation of functional occlusion and the physiological adaptation of alveolar bone to orthodontic forces^{14 15}. The maintenance of bone density in these patients underscores the importance of early interventions to prevent bone deterioration following tooth loss.

Histological evaluations in this study revealed notable differences between the groups in cortical bone thickness and trabecular density. Partial denture users displayed thinner cortical bone and lower trabecular density, consistent with findings that reported that bone quality diminishes without natural teeth¹⁶⁻¹⁸. The increased inflammatory cell infiltration observed in denture users further highlights the impact of prosthetic devices on soft tissue and bone health, likely due to chronic irritation or microbial colonisation. Orthodontic patients, on the other hand, demonstrated thicker cortical bone and higher trabecular density, reflecting a healthier bone structure. These findings align with Frost's mechanistic theory, which suggests that mechanical loadings, such as orthodontic forces, influence bone remodelling^{19 20}.

Vascularisation, an essential indicator of bone health, was significantly reduced in partial denture users compared to orthodontic patients. This result supports previous studies that highlight the role of blood supply in maintaining bone viability. Adequate vascularisation in orthodontic patients may contribute to preserving bone density and overall ridge health²¹.

The observed differences in functional and structural outcomes between the groups emphasise the need for tailored treatment strategies. Denture users would benefit from interventions that minimise bone loss, such as bone grafting or implant-supported prostheses, which have been shown to preserve ridge dimensions better than conventional dentures²². Maintaining ridge health during and after treatment is critical for orthodontic patients, particularly if prosthetic rehabilitation is planned.

Overall, this study's results align with existing literature, emphasising the long-term impact of tooth loss and treatment modalities on alveolar ridge characteristics. While partial dentures provide a functional replacement for missing teeth, their limitations in preserving alveolar bone integrity are evident. Conversely, orthodontic treatment offers a more favourable environment for maintaining bone health, underscoring the importance of proactive and individualised treatment planning to address the specific needs of these patient populations.

Future studies could expand on these findings by incorporating larger sample sizes and exploring additional variables such as systemic health factors, dietary influences, and long-term outcomes of various prosthetic and orthodontic interventions.

CONCLUSION

This study highlights significant differences in the radiographic and histological characteristics of the alveolar ridge between partial denture users and orthodontic patients with congenitally missing teeth or those who require tooth extraction as part of their orthodontic. Partial denture users experienced more significant ridge resorption, reduced bone density, thinner cortical bone, and compromised vascularisation compared to orthodontic patients. These findings underscore the detrimental effects of prolonged edentulism and denture use on alveolar bone health.

In contrast, orthodontic patients demonstrated better-preserved ridge dimensions and superior bone quality, likely due to the positive influence of orthodontic forces on bone remodelling and maintenance.

These results emphasise the importance of early intervention strategies to prevent bone loss, such as implant-supported prostheses for denture users or timely orthodontic treatment for patients with missing teeth.

The study provides valuable insights for clinicians, highlighting the need for individualised treatment planning to optimise bone health and improve long-term outcomes for denture users and orthodontic patients. Future research could expand on these findings by exploring additional factors influencing alveolar ridge health, such as systemic health conditions, prosthetic design improvements, and long-term outcomes of various treatment approaches.

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