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Evaluation of the local factors affecting periodontal bone loss using cone-beam computed tomography

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Abstract

Aim: This study aimed to investigate the impact of local factors, such as fillings, caries, and crowns, on periodontal bone loss across different age groups using cone beam computed tomography images.
Methodology: A total of 200 CBCT images of individuals from diverse age groups (19 years and older) were examined in this study. The distance between the alveolar ridge (AR) and the cemento-enamel junction (CEJ) was assessed. Measurements up to 2 mm were considered normal, while values surpassing this threshold were regarded as indicative of bone loss. Furthermore, a comparison was made between areas affected by local factors, such as fillings, crowns, and caries, and unaffected regions in terms of the extent of bone loss.
Results: The study findings revealed that the extent of bone loss was significantly lower in teeth without fillings on interproximal surfaces compared to those with fillings ($p<0.05$). Conversely, no significant relationship was observed between caries on mesial surfaces and bone loss. Additionally, the study found that teeth without caries on distal surfaces exhibited significantly lower bone loss compared to decayed teeth ($p<0.05$). A statistically significant difference was noted between crowned and uncrowned teeth in terms of mean bone loss values ($p<0.05$). Teeth without crowns demonstrated significantly lower mean bone loss compared to those with crowns.
Conclusion: Local factors, including dental restorations, caries, and crowns, have been shown to significantly impact periodontal health and to be associated with an increased susceptibility to periodontal destruction. It is essential to promptly address decayed teeth contributing to food entrapment and plaque retention, ensuring that restorations are properly placed within physiological boundaries to maintain optimal oral hygiene.

Keywords: Alveolar bone loss, caries, dental restorations, crowns, cone-beam computed tomography

Introduction

Periodontitis is a prevalent condition in the general population, and its progression is primarily driven by periodontopathogenic microorganisms and the immune responses of individuals against these microorganisms. Clinical attachment loss, radiographically evident alveolar bone loss, periodontal pocket formation, and gingival bleeding are key manifestations of this disease (1, 2). The severity of the impact of microorganisms on periodontal tissue destruction may vary due to systemic or local factors (3). Numerous risk factors contribute to the development of periodontal diseases, including nonmodifiable factors, such as age and genetic characteristics, and modifiable factors, such as inadequate oral hygiene, smoking, and pregnancy (4,5). Local risk factors for periodontitis encompass conditions that hinder plaque removal during regular oral care or trigger increased plaque accumulation (6). These may include tooth morphology and alignment, furcation anatomy, caries near the gingival margin, the status of dental restorations, occlusal trauma, gingival shape, interdental contact, and other anatomical features. These factors influence plaque buildup and contribute to variations in the severity of periodontal destruction across different teeth and surfaces (6, 7).

A study investigating the correlation between carious lesions or dental fillings and periodontitis has shown that these factors contribute to an increased incidence of periodontal destruction (8). The concept of biological width becomes crucial when restorations are positioned below the gum line in an aesthetically and functionally appropriate manner. Biological width refers to the combined thickness of the connective tissue (1.07 mm) and epithelium (0.97 mm) surrounding natural teeth, acting as a protective mechanism in the vulnerable area where teeth emerge from the oral environment (9). Violation of biological width via restorations can elicit two distinct responses. The first response involves alveolar bone loss and gingival recession, which serve as mechanisms to restore the proper biological width. However, if these reparative processes fail, chronic inflammatory processes may ensue (10). According to established clinical guidelines, if crown edges are positioned within a gingival groove, the restoration should terminate at the coronal aspect of the groove base (11). Extensive research has been conducted to examine the effects of restoration margins on periodontal health and oral hygiene, and the results have demonstrated that restoration margins placed at the gingival level or above are optimal for achieving a favorable periodontal response (12). The relationship between periodontal health and dental restorations is remarkably intertwined. Preserving gingival health is crucial for ensuring the long-term success and durability of both natural teeth and restorations (13).

Excessively contoured and overhanging restorations have been found to contribute to the accumulation of dental biofilm and the localized onset of periodontal infection. Thus, it is crucial to establish a conducive environment that facilitates the efficient removal of dental biofilm during periodontal treatment. This can be accomplished by addressing and rectifying excessively contoured, overhanging, or irregular restorations (14).

While conventional and digital radiographs have traditionally been utilized for diagnosing periodontal diseases, they have limitations in accurately tracking changes in alveolar bone over time and assessing the structure of bone defects. As a result, there has been a growing demand for three-dimensional imaging methods to address these inadequacies and to provide more comprehensive insights into periodontal conditions (15).

The primary objective of utilizing CBCT images in periodontal reconstruction is to accurately depict the morphology of the alveolar bone through three-dimensional mapping (16). This is especially crucial due to the variable and intricate resorption patterns that can occur in periodontal bone in the presence of disease. Studies have demonstrated that determining bone levels using panoramic images reconstructed with CBCT, employing a total beam thickness of 5.1 mm (mean error = 0.47 mm), yields superior accuracy compared to conventional panoramic radiographs (17).

The objective of this research was to evaluate periodontal bone loss across different age groups using CBCT and to examine the impact of specific local factors, including fillings, caries, and crowns, on the extent of bone loss.

Materials and Methods

This research received approval from the Ethics Committee of Dicle University Faculty of Dentistry, under protocol number 2022-07, on February 28, 2022. Patient consent was obtained for the utilization of archival CBCT images employed in the study. Moreover, this scientific investigation was conducted in adherence to the ethical guidelines set forth in the Declaration of Helsinki of 1964.

We conducted a retrospective analysis of cone-beam computed tomography (CBCT) images taken from patients who sought treatment at Dicle University Faculty of Dentistry between January 2018 and January 2021, regardless of the reason for their visit. In total, we utilized CBCT images from 200 patients who met the inclusion criteria of being aged 19 and above and possessing at least 20 teeth. Efforts were made to achieve an equal representation of males and females. CBCT images that lacked diagnostic value, had unclear visibility, or contained artifacts that hindered the assessment of bone loss were excluded from the study, resulting in images of 4929 teeth. To ensure consistency, all measurements were made by a single investigator.

The CBCT images were taken using the KaVo Dental I-CAT Vision (I-CAT®, Imaging Sciences Int., Hatfield, PA, USA) a 3D imaging device located in the Department of Oral Diagnosis and Radiology at the Faculty of Dentistry, Dicle University. The imaging parameters were as follows: 120 kVp tube voltage, 5 mA tube current, 1.2

mm slice thickness, 8-9 second scan time, and a voxel size of 0.3 mm.

Radiographic Evaluation

All CBCT images were saved in Digital Imaging and Communications in Medicine (DICOM) format. They were then transferred to the i-CAT Vision computer software (CT Dent Ltd. London, UK) program where the measurements were taken by the same operator, ensuring consistency and eliminating potential inter-operator variability.

After determining the dental arch in axial, coronal, and sagittal sections, a cross-sectional panoramic image was generated. The measurements of each tooth were adjusted using the same cross-sectional thickness, and the level of the alveolar bone on the mesial and distal surfaces of the teeth was determined by measuring the distance between the cemento-enamel junction (CEJ) and the highest visible level of the alveolar ridge (AR). Any distance greater than 2 mm was classified as bone loss (Figs. 1, 2).

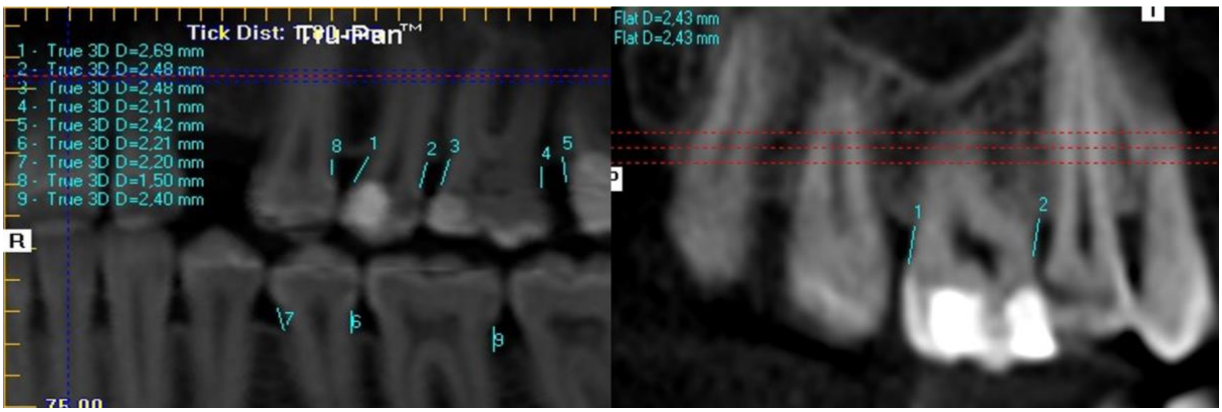

Figure 1. Measurement of the distance between the CEJ and the AR in filled and unfilled teeth in the posterior regions.

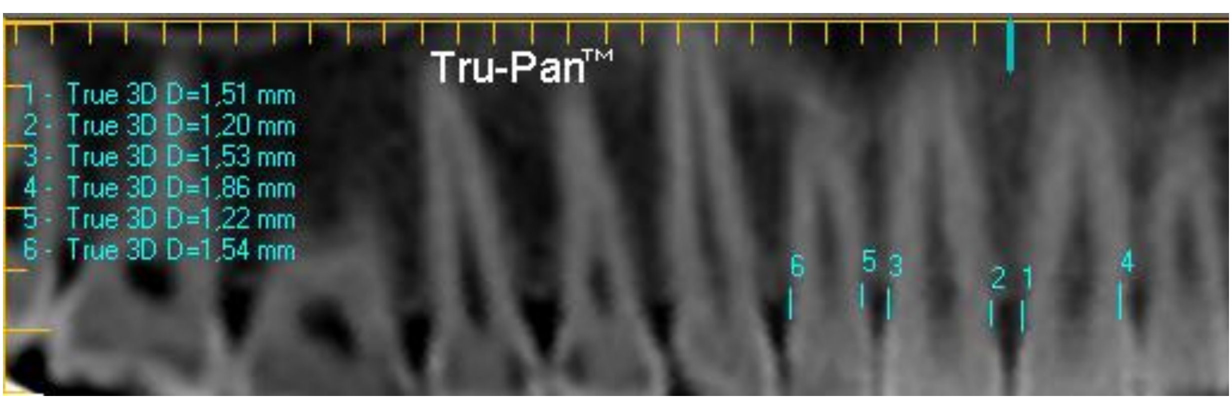

Figure 2. Measurement of the distance between the CEJ and the AR in the upper anterior teeth.

Statistical analysis

The data obtained from the CBCT images were analyzed using IBM SPSS 21 package software (IBM Inc., Armonk, NY, USA). To determine whether the variables followed a normal distribution, we employed either the Shapiro-Wilk test or the Kolmogorov-Smirnov test depending on the number of units in the dataset. A significance level of 0.05 was used. If the p-value obtained from the test was less than 0.05 ($p<0.05$), it was concluded that the variable did not exhibit a normal distribution. Conversely, if the p-value was greater than 0.05 ($p>0.05$), it was concluded that the variable did follow a normal distribution.

The Mann-Whitney U test was employed to compare variables without normal distribution between two groups, and the Kruskal-Wallis H test was employed to compare more than two groups. In cases where a significant difference was observed using the Kruskal Wallis-H Test, a Post-hoc Multiple Comparison Test was conducted to ascertain the specific differences between the groups. Finally, the relationships between groups of nominal variables were assessed using Pearson Chi-Square analysis.

Spearman's Correlation Coefficient was utilized to examine the relationship between variables that do not follow a normal distribution. During the interpretation of the results, a significance level of 0.05 was employed. It was determined that a significant difference exists when the *p*-value is less than 0.05 ($p<0.05$), indicating a meaningful association between the variables. Conversely, if the p-value is greater than 0.05 ($p>0.05$), it was concluded that there is no significant difference, suggesting a lack of substantial relationship between the variables.

Results

In our study, a total of 200 CBCT images of patients were analyzed, and the measurements were conducted on these images. The demographic characteristics of these patients can be found in Table 1. The age of the patients ranged from 19 to 69 years, with a mean age of 39.24 ± 11.40 years.

Based on cross-sectional panoramic images created using cone-beam computed tomography, the observed data indicates that the prevalence of mesial caries in teeth was 2.07%, while the rate of distal caries was 2.6%. Further analysis revealed that 3.79% of teeth had fillings on the mesial surface, whereas 4.36% exhibited fillings on the distal surface (Table 2). Additionally, the study found that the rate of teeth restored with crowns was 4.2%.

Table 1. Frequency distribution table for demographic information

		n	%
Age group	19-29 years of age	50	25
	30-39 years of age	50	25
	40-49 years of age	50	25
	50 years and older	50	25
	Total	200	100
Gender	Female	100	50
	Male	100	50
	Total	200	100
Jaw	Lower	2471	50.13
	Upper	2458	49.87
	Total	4929	100
Tooth type	Molar	1178	23.9
	Premolar	1409	28.59
	Canine	783	15.89
	Incisor	1559	31.63
	Total	4929	100

Table 2. Frequency distribution table of decayed, filled and crowned teeth

	No		Yes		Total	
	n	%	n	%	n	%
Mesial Caries	4827	97.93	102	2.07	4929	100
Distal Caries	4801	97.4	128	2.6	4929	100
Mesial Filling	4742	96.21	187	3.79	4929	100
Distal Filling	4714	95.64	215	4.36	4929	100
Crowned Tooth	4722	95.8	207	4.2	4929	100

Table 3. Analysis results regarding the difference between the values of bone loss and bone level and the presence of caries on the mesial surface of the teeth

		Mesial Caries						Mann Whitney U Test		
		n	Mean	Median	Min	Max	Sd	Mean Rank	z	p
Mesial CEJ-AR	No	4827	2.79	2.4	0.62	12.73	1.53	2464.71	-0.1	0.92
	Yes	102	2.73	2.49	1.08	8.59	1.34	2478.95		
	Total	4929	2.79	2.45	0.62	12.73	1.52			
Mesial bone loss	No	4827	0.98	0.44	0	11	1.36	2464.46	-0.189	0.85
	Yes	102	0.9	0.49	0	7	1.19	2490.65		
	Total	4929	0.98	0.45	0	11	1.36			

The statistical analysis conducted for assessing the relationship between alveolar bone level values measured from the mesial surfaces and the presence of caries on those surfaces did not yield any statistically significant difference ($p>0.05$). Similarly, no statistically significant difference was observed between the bone loss values on the mesial surfaces and the presence of caries ($p>0.05$) (Table 3).

Table 4. Analysis results regarding the difference between the values of bone loss and bone level and the presence of caries on the distal surface of the teeth

		Distal Caries						Mann Whitney U Test		
		n	Mean	Median	Min	Max	Sd	Mean Rank	z	p
Distal CEJ-AR	No	4801	2.79	2.44	0.61	11.73	1.52	2453.96	-3.335	0.001
	Yes	128	3.16	3	1	9	1.51	2878.92		
	Total	4929	2.8	2.45	0.61	11.73	1.52			
Distal bone loss	No	4801	0.98	0.44	0	10	1.35	2454.13	-3.373	0.001
	Yes	128	1.29	1	0	7	1.37	2872.82		
	Total	4929	0.99	0.45	0	10	1.36			

A statistically significant difference was found in the measured bone loss and distal caries status values on the distal surfaces (p<0.05). Teeth without caries on the distal surfaces exhibited significantly lower levels of bone loss than did teeth with caries (Table 4).

Table 5. Analysis results of the difference between bone loss and bone level values and mesial filling status

		Filling at Mesial surface						Mann Whitney U Test		
		n	Mean	Median	Min	Max	Sd	Mean Rank	z	p
Mesial CEJ-AR	No	4742	2.78	2.43	0.62	12.73	1.53	2448.98	-3.98	0.001
	Yes	187	3.05	2.72	1.2	8.63	1.33	2871.2		
	Total	4929	2.79	2.45	0.62	12.73	1.52			
Mesial bone loss	No	4742	0.97	0.43	0	11	1.37	2450.77	-3.635	0.001
	Yes	187	1.12	0.72	0	7	1.24	2825.79		
	Total	4929	0.98	0.45	0	11	1.36			

A statistical analysis revealed significant differences (p<0.05) in the mesial alveolar bone level and the presence of fillings on the mesial surfaces. The distance of the alveolar bone level in teeth with fillings on the mesial surfaces was significantly higher than that of teeth without fillings (Table 5).

An analysis was conducted on the mesial bone loss and the presence of fillings on the mesial surfaces, revealing a statistically significant difference between them (p<0.05). Teeth without fillings on the mesial surfaces exhibited significantly lower levels of bone loss compared to teeth with mesial surface fillings (Table 5).

Table 6. Analysis results regarding the difference between bone loss and bone level values and filling status on distal surfaces

		Filling at Distal surface						Mann Whitney U Test		
		n	Mean	Median	Min	Max	Sd	Mean Rank	z	p
Distal CEJ-AR	No	4714	2.78	2.43	0.61	11.73	1.52	2437	-6.469	0.001
	Yes	215	3.33	3.04	1	9.01	1.49	3078.92		
	Total	4929	2.8	2.45	0.61	11.73	1.52			
Distal bone loss	No	4714	0.97	0.43	0	10	1.35	2439.63	-6.017	0.001
	Yes	215	1.39	1.04	0	7	1.42	3021.2		
	Total	4929	0.99	0.45	0	10	1.36			

Statistical analysis revealed a statistically significant difference (p<0.05) between the alveolar bone level values measured on the distal surfaces and the presence of fillings on those surfaces. Teeth without distal surface fillings exhibited significantly lower levels of alveolar bone than did teeth with distal surface fillings (Table 6).

This study examined the bone loss values and filling status on distal surfaces and revealed statistically significant differences between these conditions (p<0.05). Teeth without fillings on the distal surfaces displayed significantly lower bone loss than did those with fillings (Table 6).

Table 7. Analysis results regarding the differences among bone loss and crowned teeth

		Tooth with crown						Mann-Whitney U test		
		n	Mean	Median	Min	Max	Sd	Mean Rank	z	p
Mesial bone loss	No	4722	0.96	0.42	0	11	1.37	2423.94	-9.949	0.001
	Yes	207	1.5	1.31	0	8	1.12	3401.6		
	Total	4929	0.98	0.45	0	11	1.36			
Distal bone loss	No	4722	0.96	0.42	0	10	1.36	2422.48	-10.288	0.001
	Yes	207	1.6	1.45	0	7	1.18	3435.02		
	Total	4929	0.99	0.45	0	10	1.36			
Mean bone loss	No	4722	0.96	0.45	0	9.97	1.3	2421.15	-10.514	0.001
	Yes	207	1.55	1.46	0	6.42	1.04	3465.33		
	Total	4929	0.98	0.5	0	9.97	1.3			

A statistically significant difference was observed in both the mesial and distal bone loss values when comparing the presence of crown restoration ($p<0.05$). Bone loss in the mesial and distal regions of teeth with crown restorations was significantly higher than in unrestored, intact teeth (Table 7). Additionally, the mean bone loss value in teeth without crowns was significantly lower than in teeth with crowns ($p<0.05$).

Discussion

Numerous studies have investigated the effectiveness of CBCT in diagnosing periodontal conditions, consistently demonstrating highly reliable outcomes in assessing both horizontal and vertical bone loss (16). Mohan et al. conducted research exploring the diagnostic potential of CBCT for periodontal diseases, concluding that it is a suitable imaging modality for periodontal evaluation (18). Furthermore, Mol and Balasundaram emphasized the superiority of CBCT over periapical films in evaluating horizontal bone loss (19). Another study conducted by Faria Vasconcelos et al. revealed that CBCT provided more accurate measurements compared to periapical films when determining the level and location of alveolar bone (20). Building upon these findings, which indicate that interproximal bone loss assessment using CBCT images is accurate and reliable, we opted to employ cone-beam computed tomography images in our own investigation of periodontal bone loss.

Smaller voxel sizes are recommended for assessing structures that necessitate a more comprehensive evaluation, such as periodontal space and alveolar crest, in CBCT images (15, 21). The voxel size used in our study was 0.3 mm, which is in line with the recommended voxel size.

The position of the alveolar crest on radiographs is determined in relation to the cemento-enamel junction (CEJ), and numerous studies in the literature have examined the CEJ (22). Cement typically contains 45-50% inorganic hydroxyapatite, while enamel contains 97% hydroxyapatite (23). As a result of the distinct densities of these two tissues, such as enamel and cement, the CEJ is clearly visible on both radiographs and CBCT images (22). Consequently, studies that utilize the CEJ border as a reference point exhibit high accuracy and reproducibility in their measurements (22). In consideration of this information, our study performed measurements of bone level and periodontal bone loss, with the CEJ serving as a reference.

Several studies have utilized the distance from the cemento-enamel junction (CEJ) to the alveolar ridge as an indicator of bone loss. A commonly referenced threshold value for the amount of alveolar bone relative to the CEJ in healthy young individuals is 2 mm; this value has been used in numerous studies (3, 24). Epidemiological studies have generally regarded 1 to 3 mm to be a normal size range for the alveolar ridge (25). Our study, which involved a similar age group as those mentioned in previous studies, also adopted the value of 2 mm as the normal distance between the CEJ and the alveolar ridge.

The severity of bone destruction in periodontal diseases is known to be primarily influenced by factors such as the initial bone level of the patient, age, and tooth type. However, there have been reports in other studies suggesting that gender, dental calculus, and crown and restoration margins can also have a direct effect on bone destruction. It is important to note that there are relatively few cross-sectional studies on this specific subject (26).

Various studies have indicated that a majority of dental restorations and fillings exhibit protrusions and other incompatibilities (27). Improperly placed restorations can lead to increased plaque retention, impede oral hygiene procedures, and disrupt local microflora (28). As a consequence, significant gingivitis and destruction of the periodontal tissue can occur (5, 29, 30). Several studies have reported that faulty restorations, such as overhanging fillings, can contribute to bone destruction and increased attachment loss (30, 31). For instance, Pack et al. found a strong correlation between the edges of overhanging amalgam restorations and significant gingivitis and periodontal bone destruction (32). Similarly, Hakkarien et al. explained that overhanging restorations can cause severe periodontal destruction of the adjacent alveolar bone (33). In studies evaluating both compatible and incompatible restorations, an increase in periodontal tissue loss was observed in both groups (8).

Our study is retrospective and investigated X-ray images. Bone height before the placement of restorations such as fillings and crowns is not known. This constitutes the most important limitation of our study. The detected bone loss may have occurred before the caries was treated or may have developed after the restorations were completed. It is not possible to state this exactly. However, in different studies, it has been reported that bone loss in filled areas is mostly related to restorations and that the initial caries affects the situation less (34). Our study aligns with these studies. According to our results, there is a significant relationship between filled surfaces and bone loss. Alveolar bone loss is more severe in teeth with fillings on the mesial or distal surfaces compared to teeth without fillings.

In our study, we evaluated the impact of caries, fillings, and crowns on periodontal bone loss in a general context. Specifically, we found that teeth with caries on the distal surfaces exhibited higher levels of bone loss compared to teeth without caries. These findings align with previous studies (28, 33, 35) that have reported similar outcomes. However, we did not observe any correlation between dental caries on mesial surfaces and periodontal bone loss. Albandar et al. (8) have previously noted that periodontal tissue loss tends to increase on surfaces with untreated caries lesions adjacent to the gingiva; however, initial caries did not appear to have an impact on bone loss. In our study, we considered caries in a general sense without distinguishing between incipient or cavitated caries. This lack of distinction between the different stages of caries may explain the distinct relationship observed between caries and bone loss on mesial and distal surfaces.

Periodontal health and the overall well-being of periodontal tissues are influenced by various factors, including the planning, design, and maintenance of fixed restorations (36). Ensuring accurate periodontal evaluations can significantly extend the longevity of both the fixed prosthesis and the underlying abutment teeth providing support. Several factors have been identified as potentially impacting the periodontium, including the positioning of the restoration within the gingival sulcus, properties of the dental material used, presence of overhanging edges, periodontal phenotype, prosthesis emergence profile, and biologic width (6, 36).

Bader et al. conducted a study comparing the effects of crowned teeth and normal teeth, and their findings indicated that crowned teeth exhibited increased gingival recession, attachment and bone loss, and pocket depth (37). Several studies have also reported that the impact of subgingival placement of restoration margins on periodontal health, suggesting that it increases the risk of alveolar bone loss and plaque retention (5, 38–40). Orkin et al. observed a significant increase in plaque accumulation, gingivitis, and gingival recession specifically at the edges of crowns placed subgingivally, while supragingival restorations showed a comparatively lesser increase in these parameters (41).

The preservation of the integrity of the dentogingival unit is considered the most crucial factor in subgingival placement of restorations. Researchers have recommended limiting the preparation margins to be between 0.5 and 1 mm subgingivally in order to maintain this integrity (10). Our study aligns with these findings and supports this recommendation. We observed that teeth restored with crowns exhibited a higher degree of bone loss compared to teeth without restorations.

Conclusion

Our study findings, along with the limitations we have identified, suggest that periodontal bone loss is directly influenced by local predisposing factors such as fillings, caries, and crowns. In conclusion, while our study's results align with previous research in this area, it has a unique aspect in terms of utilizing retrospective analysis of cross-sectional and reconstructed panoramic images from cone-beam computed tomography (CBCT) to establish the correlation between fillings, caries, fixed prosthetic restorations, and alveolar bone loss.

This study underscores the importance of considering this information prior to initiating periodontal treatment. Specifically, addressing overhanging restorations, treating caries, and replacing fixed prosthetic restorations that do not comply with biological limits are crucial steps for enhancing the success of periodontal treatment.

Disclosures

Ethical Approval: Ethics committee approval was received for this study from the Dicle University, Faculty of Dentistry, Local Ethics Committee, in accordance the World Medical Association Declaration of Helsinki, with the approval number: 2022-007

Peer-review: Externally peer-reviewed.

Author Contributions: Conception – G.S.; Design – G.S., A.D.; Supervision – A.D.; Materials – G.S., A.D.; Data Collection and/or Processing – G.S., A.D.; Analysis and/or Interpretation – G.S.; Literature Review – G.S.; Writer –G.S.; Critical Review – A.D.

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