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Original Article

Association of Systemic Diseases with Bone Loss around Implants: A Cross-Sectional Radiographic Study

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ABSTRACT

This cross-sectional radiographic study aims to evaluate the prevalence and extent of peri-implant bone loss in patients with systemic conditions and to explore associations with age, gender, and specific systemic diseases. The study analyzed 306 patient records from dental clinics, focusing on those with systemic conditions and dental implants placed at least one year prior. Periapical radiographs were assessed for mesial and distal bone loss, classified into three levels (Class I, II, and III). Data were statistically analyzed using SPSS, with a significance level set at $p \leq 0.05$.Among participants, diabetes mellitus was the most prevalent systemic condition (60%), followed by hypertension (13.3%). Bone loss was observed in 26.7% of patients, with Class I (mild) being the most common (65.9%). Gender-based analysis revealed a higher prevalence and severity of bone loss in females (38% prevalence) compared to males (23%). Age-wise, bone loss prevalence significantly increased with age ($p = 0.002$), with 83% of patients aged 50+ experiencing bone loss. Systemic diseases such as diabetes and hypertension are strongly associated with increased peri-implant bone loss, particularly in older adults and females. Radiographic evaluations are crucial for early detection and management of peri-implant bone loss in patients with systemic conditions to enhance the long-term success of dental implants.

Keywords: Dental implants, Bone loss, Systemic diseases, Implant failure

Introduction

Dental implants have proved to be one of the most effective solutions for offering the patient a functional and aesthetic replacement of lost teeth. Nevertheless, less attention has been given to the fact that even though the overall success rate of dental implants is very high, there is an increased tendency to develop peri-implant diseases, and more specifically, peri-implantitis, which may compromise the long-term stability of the implants. Peri-implantitis can be defined as inflammation of the peri-implant mucosa and progressive loss of the bone supporting the implant, with the potential of implant loss [1]. Due to various factors, the rate at which Peri-implant bone resorption occurs may vary, and some of the factors include bacterial infection, poor technique of oral hygiene, and, most especially, systemic diseases. It has been identified that diseases that affect the entire body system, including diabetes mellitus, cardiovascular diseases, and osteoporosis, contribute to aggravating peri-implant bone loss and thereby increasing the chances of implant failure [2, 3].

Peri-implant bone is of great importance to the stability and longevity of dental implant procedures since the bone offers anchorage for implants. Osseointegration is achieved when there is a stable direct apposition of the living bone to the surface of a load-bearing implant, which forms the basis of dental implants. When systemic conditions affect bone metabolism, immune response, and tissue healing, they can result in the acceleration of Implant bone loss [4]. Radiographic examination is used prominently in evaluating the levels of the bone around implants and can help identify changes indicating bone loss. Therefore, the purpose of the current cross-sectional radiographic

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study is to investigate the prevalence of factors affecting peri-implant bone loss and implant success that may be related to systemic diseases, including diabetes, osteoporosis, and cardiovascular diseases [5].

The literature abounds with data proving the relationship between systemic diseases as a cause of peri-implant bone loss. Among those factors, diabetes mellitus is one of the conditions that have been scientifically proven to be related to the development of peri-implantitis and bone loss. Diabetic patients with poorly controlled diabetes-related conditions have higher inflammation levels and poor wound healing ability, which increases peri-implant bone resorption [6]. Peri-implant tissues are chronically inflamed due to hyperglycemic effects on the immune system associated with diabetes and consequent release of pro-inflammatory cytokines. In fact, diabetic patients have been reported to develop peri-implantitis, which also results in more bone loss around the implants than non-diabetic patients [1]. In agreement with this connection, Monje *et al*. (2017) conducted a systematic review. They demonstrated that the prevalence of peri-implantitis was higher in diabetic patients than in non-diabetic patients, particularly those with poor glycemic control.

Osteoporosis may be another systemic disease that is characterized by low bone density and high bone fragility. The risk of bone loss around dental implants is highly prevalent in osteoporotic patients, largely due to their poor bone quality [7]. In one of the findings done by Dalago *et al*. (2017), it was deemed that due to the reduced bone mineral density observed in osteoporotic patients, the rate at which the implant integrates with the bone or osseointegration is reduced, and, therefore, the patient is likely to experience an increased rate of peri-implant bone resorption in the future [8]. A more recent cross-sectional study by Galárraga-Vinueza *et al*. (2020) showed higher levels of bone loss in osteoporotic patients than in the healthy control group [4]. They highlighted the reason for the reduced regenerative ability of the osteoporotic bone, which may challenge the viability of the implant in the long run, where other risk factors like poor oral hygiene exist. Moreover, the role of early intervention and strict control of the peri-implant bone crystal density in osteoporotic patients was also stressed in the study [4].

Diseases affecting the cardiovascular system, and most particularly hypertension, have also been cited as a cause of increased progression of peri-implant bone loss. Hypertension plays a role with respect to the blood supply of peri-implant tissues since blood flow is reduced and recovery is slowed down. This means that there is decreased blood flow to the implants, which, in turn, causes increased bone resorption [9]. Matarazzo *et al*. (2018) conducted a study to establish that the subject population that has cardiac ailments is more susceptible to peri-implant bone loss, especially if the patient's blood pressure is hardly manageable [10]. Cardiovascular-associated inflammatory response significantly aggravates bone loss, which must be considered during the dental implant treatment of cardiovascular patients.

Peri-implant bone loss is, therefore, best determined by comparing radiographic assessment with other diagnostic tools [11]. Clinical parameters are easily measurable and can give information on probe depth, bleeding, suppuration, and overall pocket depth; however, radiographic parameters present essential data about bone levels around implants and help clinicians determine early signs of peri-implantitis and profile the bone loss over time [11]. Radiographic analysis is more crucial in patients with systemic diseases since such patients are at higher risk of developing peri-implantitis and bone resorption. Molecular data have revealed that 75.4% of the subjects with radiographic evidence of bone loss had clinical signs of peri-implantitis, including BOP(+), PD≥5mm [4]. Clinical and radiographic examination gives a holistic picture of peri-implant health and is useful in managing patients with systemic diseases.

Study rationale

Systemic conditions affect inflammatory and immune processes, negatively influence bone tissue repair, and increase the bone resorption rate. Screening and treating peri-implantitis at an early stage cannot be overemphasized if the dental implants in these groups of patients are to be viable for the long term.

Hypothesis

There is a significant association between systemic diseases with bone loss around implants.

Aims and objectives

The main aim of the study is to determine the prevalence of bone loss around implants among patients with systemic conditions (diabetes, cardiac disease, kidney disease, hypertension, radiotherapy, chemotherapy).

Further objectives include measuring the extent of bone loss and assessing comparisons between gender and age groups.

Materials and Methods

Research design

This study employed a cross-sectional design to uncover the prevalence of bone loss around implants among patients with systemic disease.

Study setting

This study took place in the clinics of REU campuses using the files of previously treated patients with dental implants.

Sample of the study

A sample of 306 patients was included in this study. Patients with a history and complete record of at least one systemic condition with an implant placed were included in this study. Margin of error was 5%, confidence interval 95% and population size 1500 (www.raosoft.com).

Inclusion criteria

- Patients with at least one systemic condition (diabetes, cardiac disease, kidney disease, hypertension, radiotherapy, chemotherapy).
- Patients with at least one implant.
- Patients with implant placement within one year.

Exclusion criteria

- Patients with no systemic diseases.
- Patients with an implant placed within a year.

Data collection

Each peri-apical radiograph was examined by two examiners to ensure inter-examiner reliability. Systemic conditions such as diabetes, cardiac disease, kidney disease, hypertension, radiotherapy, chemotherapy, etc., were recorded if they were found in the patients. Bone loss was determined using a digital measurement tool, and mesial and distal bone loss were measured from the first bone-to-implant contact and implant-abutment interface.

Statistical analysis

Data were inserted into SPSS version 21 to achieve the descriptive and inferential analysis. Findings are presented in the form of tables and figures. Comparisons between groups were made with a p-value of 0.05 or less to be statistically significant using the Chi-square test.

Results and Discussion

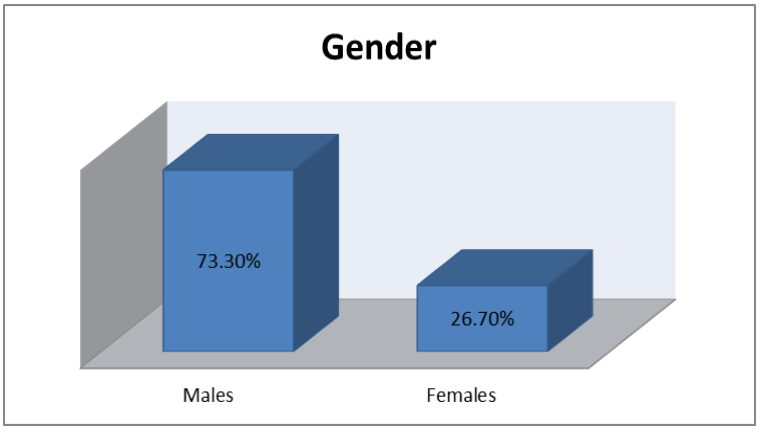

Figure 1. Male and female distribution of participants in the sample

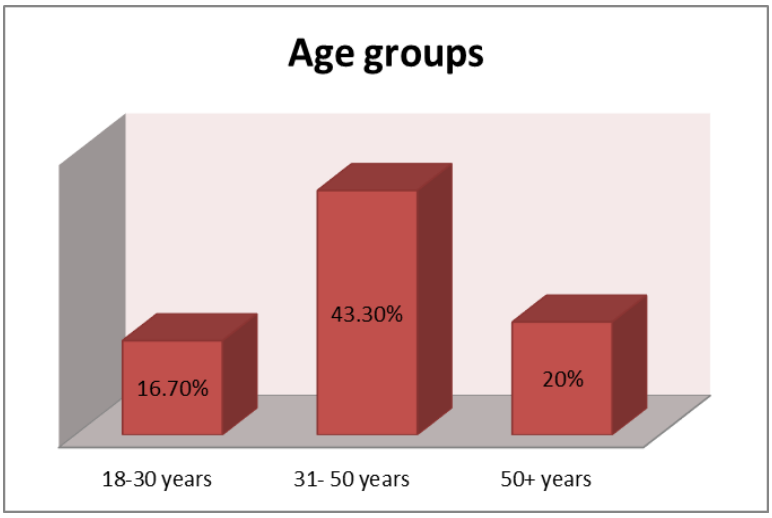

Figure 2. Age groups of study participants

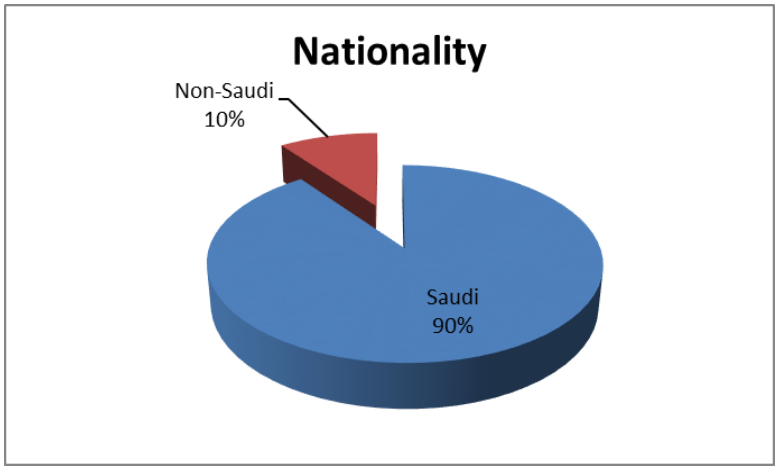

Figure 3. Nationality of study participants

Table 1. Descriptive analysis of the systemic diseases and bone loss

Variables	Types	Frequencies
Type of systemic disease	Diabetes mellitus	198 (60%)
	Hypertension	44 (13.3%)
	Radio/Chemotherapy	11 (3.3%)
	Cardiac disease	22 (6.7%)
	Kidney disease	32 (10%)
	Others	22 (6.7%)
Prevalence of bone loss around implants	Yes	88 (26.7%)
	No	242 (73.3%)
Extent of bone loss	Class I	58 (65.9%)
	Class II	21 (23.9%)
	Class III	9 (10.2%)

Figure 1 shows the gender ratio of study participants and it can be seen that 73.3% were males and the rest being females. **Figure 2** reveals the age distribution, which showed the highest involvement of 31-50 years age group which was 43.3%. **Figure 3** shows the nationality of study participants and it was noted that 90% were Saudis. The data in **Table 1** provides an analysis of systemic diseases and their association with bone loss around implants. Among the systemic diseases, diabetes mellitus was the most prevalent, affecting 198 participants, accounting for 60% of the sample. Hypertension was the second most common condition, present in 44 participants (13.3%). A

smaller percentage of participants underwent radio/chemotherapy (3.3%), while cardiac disease was reported in 6.7% (22 participants). Kidney disease also affected a notable portion, with 32 individuals (10%). Additionally, 6.7% of participants reported other systemic conditions not listed explicitly in the table.

Regarding the prevalence of bone loss around implants, the majority of participants (242 individuals, 73.3%) did not experience bone loss. However, 88 participants (26.7%) did exhibit bone loss, highlighting a substantial minority potentially affected by this condition.

For those with bone loss, the extent was classified into three categories. Class I bone loss, representing mild loss, was the most common, affecting 58 participants (65.9%). Class II, indicating moderate bone loss, was less frequent, with 21 cases (23.9%). Severe bone loss, classified as Class III, was the least common, occurring in only 9 participants (10.2%).

This analysis underscores the relationship between systemic diseases and bone loss around implants. While the majority of individuals did not show bone loss, the presence of systemic conditions, particularly diabetes mellitus, may contribute to a higher likelihood of this complication.

Table 2. Comparison of bone loss based on gender

	Males	**Females**	**P-value**
Prevalence of bone loss around implants	Yes: 23% No: 77%	38% 63%	.006*
Extent of bone loss	Class I: 55% Class II: 33% Class III: 13%	Class I: 85% Class II: 9% Class III: 6%	.014*

Table 2 provides a comparison of bone loss around implants between males and females, showcasing significant differences in both prevalence and severity based on gender. When examining the prevalence of bone loss, it is observed that 23% of males experienced bone loss, while the majority, 77%, did not. In contrast, a higher proportion of females, 38%, showed evidence of bone loss, with 63% reporting no such issues. This difference in prevalence between males and females is statistically significant, as indicated by a P-value of 0.006, suggesting that gender plays a critical role in the occurrence of bone loss.

The extent of bone loss also varied noticeably between genders. Among males, 55% of cases were classified as Class I (mild), 33% as Class II (moderate), and 13% as Class III (severe). For females, the majority of bone loss cases, 85%, fell under Class I (mild), while Class II (moderate) and Class III (severe) were significantly less common, at 9% and 6%, respectively. These differences in the distribution of bone loss severity between males and females are also statistically significant, with a P-value of 0.014.

Table 3. Comparison of bone loss based on age

	18-30 years	**31-50 years**	**50+ years**	**P-value**
Prevalence of bone loss around implants	Yes: 31% No: 69%	Yes: 40% No: 60%	Yes: 83% No: 17%	.002*
Extent of bone loss	Class I: 82% Class II: 18% Class III: 0%	Class I: 59% Class II: 23% Class III: 18%	Class I: 64% Class II: 32% Class III: 5%	.101

Table 3 examines the prevalence and extent of bone loss around implants across three age groups: 18–30 years, 31–50 years, and 50+ years. The findings highlight significant variations in both the occurrence and severity of bone loss based on age.

When it comes to the prevalence of bone loss, the data show an increasing trend with age. In the youngest group (18–30 years), 31% of participants experienced bone loss, while the majority, 69%, did not. In the middle-aged group (31–50 years), the prevalence of bone loss rose to 40%, leaving 60% unaffected. The highest prevalence was observed in the 50+ years group, where 83% of participants experienced bone loss, and only 17% showed no signs of it. This progressive increase in prevalence across age groups is statistically significant, as indicated by a P-value of 0.002, suggesting that age is a major factor influencing the likelihood of bone loss.

The extent of bone loss also shows variation between age groups, though the differences are not statistically significant (P-value of 0.101). In the 18–30 years group, the majority of cases (82%) were classified as Class I

(mild), with the remaining 18% falling under Class II (moderate) and no cases of Class III (severe) bone loss. In the 31–50 years group, Class I bone loss decreased to 59%, while moderate cases (Class II) rose to 23%, and severe cases (Class III) accounted for 18%. Among participants aged 50+ years, the pattern shifted slightly, with 64% having Class I bone loss, 32% Class II, and 5% Class III.

In summary, the table reveals that the prevalence of bone loss significantly increases with age, while the severity of bone loss shows a slight variation across age groups. Younger individuals are more likely to experience milder forms of bone loss, while moderate and severe cases become more common in older age groups.

Table 4. Comparison of bone loss based on systemic diseases

	Prevalence of bone loss		
	Yes	**No**	**P-value**
Diabetes mellitus	22%	78%	.000*
Hypertension	50%	50%	
Radio/Chemotherapy	0%	100%	
Cardiac disease	50%	50%	
Kidney disease	0%	100%	
Others	33%	67%	
Diabetes mellitus	Class I: 68%, Class II: 14%, Class III: 18%		.000*
Hypertension	Class I: 68%, Class II: 32%, Class III: 0%		
Cardiac disease	Class I: 91%, Class II: 0%, Class III: 9%		
Others	Class I: 27%, Class II: 73%, Class III: 0%		

Table 4 investigates the prevalence and extent of bone loss around implants in participants with different systemic diseases, revealing significant associations. The prevalence of bone loss varies greatly depending on the specific condition, as reflected by a statistically significant P-value of 0.000. Among individuals with diabetes mellitus, 22% showed bone loss, while 78% did not. For participants with hypertension and cardiac disease, the prevalence was evenly distributed, with 50% experiencing bone loss and 50% unaffected in both groups. Interestingly, participants undergoing radio/chemotherapy and those with kidney disease exhibited no bone loss at all, with 100% unaffected. Participants categorized under other conditions showed a 33% prevalence of bone loss, while 67% did not experience it.

The extent of bone loss also demonstrates significant differences based on systemic disease, with a P-value of 0.000 highlighting the strong association. Among participants with diabetes mellitus, most cases fell under Class I (68%), while Class II (14%) and Class III (18%) accounted for fewer instances. Similarly, for individuals with hypertension, the majority (68%) experienced Class I bone loss, with Class II making up 32%, and no instances of Class III. Participants with cardiac disease predominantly exhibited mild bone loss, with 91% classified as Class I, 9% as Class III, and none as Class II. For those with other conditions, bone loss was more severe, with only 27% in Class I and the majority (73%) falling into Class II, while Class III cases were absent.

Comparison of present and past studies on bone loss around implants

Bone loss and gender

The present study highlights significant differences in the prevalence and severity of bone loss between males and females, with a P-value of 0.006 indicating statistical significance. Females demonstrated a higher prevalence of bone loss (38%) compared to males (23%). Additionally, the distribution of bone loss severity differed, as females predominantly exhibited Class I bone loss (85%), while males showed a more diverse distribution, with 55% in Class I, 33% in Class II, and 13% in Class III. These findings emphasize the role of gender in bone loss occurrence and severity.

Past studies, such as Manz (2000), also examined bone loss by gender but reported conflicting trends [12]. Initially, females experienced less bone loss during early follow-ups, but the severity increased in subsequent intervals, particularly by the 36-month follow-up. This discrepancy could stem from variations in sample sizes, study durations, or participant demographics. The inclusion of fewer female participants in long-term intervals (e.g., only 12 in the 48- to 60-month period) limits the generalizability of past findings.

Bone loss and age

In the present study, age significantly influenced the prevalence of bone loss, with older participants showing a higher prevalence (83% in the 50+ group) compared to younger groups (31% in the 18–30 years). The severity of

bone loss also increased slightly with age, although these differences were not statistically significant (P-value of 0.101). Class I bone loss remained predominant across all age groups, but moderate (Class II) and severe (Class III) cases were more common in older participants.

In contrast, past studies like Fransson *et al*. (2008) explored bone loss among smokers and non-smokers but noted significant age differences between these groups, potentially confounding their results [13]. The mean age was lower among smokers (67 years) compared to non-smokers (74 years), suggesting that lifestyle factors and systemic health may play a role in the observed trends.

Bone loss and systemic diseases

The present study underscores a strong association between systemic diseases and bone loss, with a P-value of 0.000 indicating significant variation. For instance, individuals with diabetes mellitus experienced 22% bone loss, while hypertension and cardiac disease each had a prevalence of 50%. No bone loss was observed among participants undergoing radiotherapy/chemotherapy or those with kidney disease. The severity of bone loss also varied, with most cases classified as Class I for diabetes (68%) and hypertension (68%), while cardiac disease showed 91% Class I and 9% Class III.

Previous studies, such as Carr *et al*. (2017) and Renvert *et al*. (2014), have suggested that cardiovascular conditions are not directly linked to implant loss but may impact long-term peri-implant tissue health [14, 15]. Diabetes, particularly when poorly controlled, has been consistently associated with higher rates of peri-implantitis and peri-implant bone loss. However, studies also report that when glycemic control (HbA1c) is maintained within physiological ranges and oral hygiene is good, the risk of inflammation and bone loss aligns with that of healthy individuals [16].

Limitations

1. *Sample size and demographics:* The study's findings may not generalize to other populations due to the limited and localized sample size. Cultural, dietary, and lifestyle differences were not explored.
2. *Short follow-up period:* The study's follow-up duration was insufficient to assess long-term trends in bone loss progression.
3. *Lack of lifestyle data:* Factors like smoking, alcohol consumption, and oral hygiene practices were not accounted for, which might influence bone loss.
4. *Systemic diseases:* The classification of systemic diseases lacked granularity, such as severity levels or treatment statuses.
5. *Radiographic assessment:* Bone loss classification relied on radiographs, which, while effective, may not capture early microstructural changes.

Future recommendations

1. *Expand sample diversity:* Future studies should include participants from diverse ethnicities, geographic locations, and socioeconomic backgrounds.
2. *Longitudinal studies:* Conduct extended follow-up studies to observe bone loss progression over time.
3. *Lifestyle variables:* Incorporate variables like smoking habits, physical activity, and oral hygiene to understand their role in bone loss.
4. *Disease management:* Assess the influence of controlled versus uncontrolled systemic diseases on bone health.
5. *Advanced imaging techniques:* Use 3D imaging or cone-beam CT to improve the accuracy of bone loss measurements.
6. *Interventional studies:* Examine the efficacy of therapeutic interventions, such as medication, dietary supplements, or surgical techniques, in mitigating bone loss.

Conclusion

This study highlights significant associations between bone loss around dental implants and factors such as gender, age, and systemic diseases. Key findings include a higher prevalence of bone loss in females and older individuals, with diabetes mellitus emerging as a critical risk factor. While the majority of cases were mild (Class I bone loss), moderate to severe loss (Classes II and III) was more frequent among older participants and those with certain systemic conditions.

The findings align with past research on systemic disease impacts but differ in gender-specific trends and age-related severity. These discrepancies emphasize the need for robust, large-scale, and long-term studies to validate observations and address gaps in current knowledge. The study contributes valuable data to the ongoing discourse on peri-implant bone loss and underscores the importance of personalized treatment strategies to mitigate risks.

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Conflict of Interest: None

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