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Longitudinal Study of Peri-Implant Crestal Bone Loss in Relation to Periodontal Status of Adjacent Teeth

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Abstract:

Background:

Dental implants are a successful therapeutic option for missing teeth, yet their long-term success can be impacted by peri-implant diseases, particularly peri-implant mucositis and peri-implantitis. These conditions involve progressive bone loss around the implant, with the periodontal health of adjacent teeth playing a crucial role in peri-implant tissue stability.

Objective:

The primary aim of this study is to longitudinally evaluate peri-implant crestal bone loss (PICBL) over an extended follow-up period, focusing on the influence of the periodontal status of adjacent natural teeth on bone stability around dental implants.

Methods:

A longitudinal observational study was conducted with a sample of 48 dental implants, categorized into two groups based on the periodontal health of adjacent teeth: healthy and periodontally compromised. Data were collected on periodontal parameters, implant placement protocols, and radiographic assessments. Crestal bone loss was measured through periapical radiographs taken at baseline, prosthetic loading, and subsequent follow-ups. Statistical analysis included mixed-effects linear regression to assess the impact of periodontal health on PICBL.

Results:

The study found that implants adjacent to periodontally compromised teeth experienced significantly greater bone loss

(mean: 0.54 mm) compared to those adjacent to healthy teeth (mean: 0.32 mm, $p < 0.01$). Periodontal parameters, including probing pocket depth and bleeding on probing, were significantly worse in the compromised group, suggesting an inflammatory pathway linking periodontal health to peri-implant bone loss. No implant failures occurred, though peri-implant mucositis was more frequent near diseased teeth.

Conclusion:

The study highlights the significant influence of adjacent periodontal health on peri-implant crestal bone loss. Implants adjacent to periodontally compromised teeth showed greater early-stage bone loss, emphasizing the need for comprehensive periodontal management before and after implant placement to optimize long-term implant success.

Keywords: Bone loss, Dental implants, Peri-implantitis, Periodontal health, Radiographic assessment

INTRODUCTION

Dental implants have become a widely accepted and successful therapeutic option for replacing missing teeth, offering both functional and aesthetic benefits. Despite their high survival rates, the long-term success of dental implants is often challenged by peri-implant diseases, particularly peri-implant mucositis and peri-implantitis, which are characterized by inflammation and progressive loss of supporting crestal bone around the implant. Understanding the dynamics of peri-implant crestal bone loss (PICBL) is crucial, as it directly influences implant stability, prognosis, and overall treatment outcomes [1].

PICBL is a multifactorial phenomenon influenced by surgical, prosthetic, biomechanical, and patient-related factors. Among these, the periodontal status of the adjacent natural teeth has gained significant attention due to its potential role in peri-implant tissue health. Periodontal disease, a chronic inflammatory condition resulting in the destruction of tooth-supporting tissues, shares many pathogenic similarities with peri-implantitis. Patients with a history of periodontitis or poor periodontal health often present increased susceptibility to peri-implant bone loss and implant failure [2]. This connection emphasizes the need for longitudinal investigations that evaluate how the periodontal condition of teeth adjacent to implants affects peri-implant bone stability over time.

Several cross-sectional and retrospective studies have suggested a strong correlation between periodontal disease and increased PICBL. However, these study designs are limited by their inability to establish causality or observe progressive changes over time. Longitudinal studies, with extended follow-up periods, provide more robust evidence by tracking bone level changes and periodontal health dynamics concurrently, allowing for better understanding of temporal relationships and risk factors involved. Such studies are critical to refine clinical protocols for implant placement, maintenance, and the management of peri-implant diseases [3].

Furthermore, biological factors such as bacterial biofilm accumulation, host immune response, and local inflammation contribute to peri-implant bone resorption. The microbial flora around periodontally compromised teeth may act as a reservoir for pathogens that colonize the implant surface, exacerbating inflammatory destruction. Additionally, biomechanical factors including implant positioning, occlusal load, and prosthetic design can further influence crestal bone remodeling. The interplay of these elements with the periodontal status of neighboring teeth demands a comprehensive, longitudinal approach to capture their cumulative impact on PICBL [4].

Recent advances in radiographic imaging techniques and standardized clinical measurements have enhanced the precision of crestal bone level assessment, enabling detailed monitoring of peri-implant bone changes. These methodologies facilitate early detection of marginal bone loss, which is paramount in preventing progression to implant failure. Longitudinal studies utilizing these tools also help identify early predictive markers for peri-implantitis, potentially linked to the periodontal condition of adjacent teeth [5].

Despite the recognized importance of the periodontal environment in peri-implant health, there remains a need for large-scale, long-term prospective studies that rigorously assess this relationship. Variations in patient demographics, implant

types, surgical protocols, and maintenance regimens complicate the generalizability of findings. Moreover, the impact of adjunctive therapies, such as periodontal treatment before implant placement and supportive periodontal care, requires further exploration in the context of peri-implant crestal bone preservation [6].

This study aims to longitudinally evaluate PICBL over an extended follow-up period, specifically examining the influence of the periodontal status of teeth adjacent to implants. By integrating clinical periodontal parameters, radiographic bone level measurements, and patient risk profiles, this research seeks to elucidate the role of adjacent periodontal health in peri-implant bone stability. The outcomes are expected to inform clinical decision-making, emphasizing the importance of periodontal assessment and management in implant dentistry to optimize long-term implant success.

METHODOLOGY

This longitudinal observational study was designed to evaluate PICBL over time, with a specific focus on the influence of the periodontal status of teeth adjacent to dental implants. The institutional ethics committee approved the study protocol, and informed consent was obtained from all participants prior to inclusion.

Study Population:

Participants were recruited from patients receiving dental implant treatment at PDM University between January 2024 and July 2024. Inclusion criteria comprised adult patients (≥18 years) with at least one endosseous dental implant placed adjacent to natural teeth. Exclusion criteria included systemic conditions affecting bone metabolism (e.g., uncontrolled diabetes, osteoporosis), recent use of medications influencing bone turnover (bisphosphonates, corticosteroids), smoking habits exceeding 10 cigarettes/day, and lack of compliance with maintenance care. Patients with untreated or active periodontal disease were included only if periodontal therapy was completed prior to implant placement.

Baseline Examination:

At baseline (implant placement or prosthetic loading), a comprehensive clinical periodontal examination was conducted on all adjacent teeth. Parameters recorded included probing pocket depth (PPD), clinical attachment level (CAL), bleeding on probing (BOP), plaque index, and mobility. The periodontal status of adjacent teeth was classified following established criteria into healthy, gingivitis, or periodontitis categories.

Implant Placement and Prosthetic Protocol

Implants were placed following standardized surgical protocols using either a one-stage or two-stage approach. Implant systems and designs were documented, and all implants were restored with fixed prostheses after osseointegration. The implant position relative to the adjacent teeth was recorded to assess potential biomechanical influences.

Radiographic Assessment:

Standardized periapical radiographs were obtained using the long-cone paralleling technique with customized positioning devices to ensure reproducibility. Radiographs were taken at implant placement (baseline), prosthetic loading, and at subsequent follow-up intervals (6 months, 1 year, and annually thereafter for a minimum of 3-5 years). Crestal bone levels were measured digitally from the implant shoulder to the first bone-to-implant contact on mesial and distal aspects using calibrated software. The amount of crestal bone loss was calculated by comparing baseline and follow-up measurements.

Follow-Up and Maintenance:

Patients were enrolled in a strict maintenance program involving professional plaque control, reinforcement of oral hygiene instructions, and periodic periodontal monitoring of adjacent teeth. Any periodontal or peri-implant interventions during the follow-up period were documented.

Data Collection and Outcome Measures

The primary outcome measure was PICBL (in millimeters) over time. Secondary measures included changes in periodontal parameters of adjacent teeth, implant survival rates, and incidence of peri-implantitis. The periodontal status of adjacent teeth was correlated with peri-implant bone loss to assess potential associations.

Statistical Analysis:

Data were analyzed using appropriate statistical software. Descriptive statistics summarized demographic and clinical variables. The influence of periodontal status of adjacent teeth on peri-implant crestal bone loss was assessed using mixed-effects linear regression models to account for repeated measurements per implant and patient. Covariates such as patient age,sex, smoking status, implant location, and prosthetic factors were included in multivariate analyses. Statistical significance was set at $p < 0.05$.

Sample Size

The sample size for this 6-month longitudinal clinical trial was determined to ensure adequate statistical power to detect meaningful differences in peri-implant crestal bone loss associated with the periodontal status of adjacent teeth. Based on prior studies evaluating crestal bone changes over similar durations, an expected mean difference in bone loss of approximately 0.3 mm with a standard deviation of 0.4 mm was considered clinically significant.

Using a significance level (α) of 0.05 and aiming for 80% power ($\beta = 0.20$) to detect this difference, a minimum of 40 implants was calculated as necessary. To accommodate potential dropouts and ensure robust subgroup analysis between implants adjacent to periodontally healthy and diseased teeth, the sample size was increased by 20%, resulting in a target enrollment of 48 implants in total.

Participants were selected to include a representative distribution of periodontal statuses in adjacent teeth, allowing assessment of the impact of periodontal health on peri-implant crestal bone loss. The final sample size balances logistical feasibility with the need for meaningful clinical and statistical outcomes during the relatively short 6-month follow-up period.

RESULT

In this 6-month longitudinal study of 48 dental implants, we aimed to assess the impact of the periodontal health of adjacent natural teeth on PICBL. The implants were split into two groups based on the periodontal status of neighboring teeth: healthy (n=25) and periodontally compromised (n=23).

- The implants adjacent to periodontally compromised teeth showed significantly greater mean crestal bone loss (0.54 mm) than those adjacent to healthy teeth (0.32 mm).
- The difference in bone loss between these groups was statistically significant ($p < 0.01$), indicating that periodontal disease in adjacent teeth may contribute to accelerated early bone resorption around implants.
- Periodontal parameters such as probing pocket depth (PPD) and bleeding on probing (BOP) were worse in teeth next to implants with higher bone loss, reinforcing the inflammatory link.
- No implant failures occurred during the 6 months, but mild peri-implant mucositis was more frequent near diseased teeth.
- Multivariate analysis confirmed the periodontal status of adjacent teeth as an independent predictor of crestal bone loss, even when controlling for other factors [**Table 1, Figure 1**].

Parameter	Adjacent Healthy Teeth (n=25)	Adjacent Periodontitis Teeth (n=23)	p-value
Mean Crestal Bone Loss (mm)	**0.32 ± 0.15**	**0.54 ± 0.22**	**<0.01**
Mean Probing Pocket Depth (mm)	**2.8 ± 0.5**	**4.3 ± 0.9**	**<0.01**
Bleeding on Probing (%)	**15%**	**55%**	**<0.01**
Peri-implant Mucositis Cases (%)	**8%**	**30%**	**0.04**

Implant Survival Rate (%)	**100%**	**100%**	**N/A**

Table 1: Comparison of Peri-Implant Bone Loss and Periodontal Parameters by Adjacent Tooth Status at 6 Months

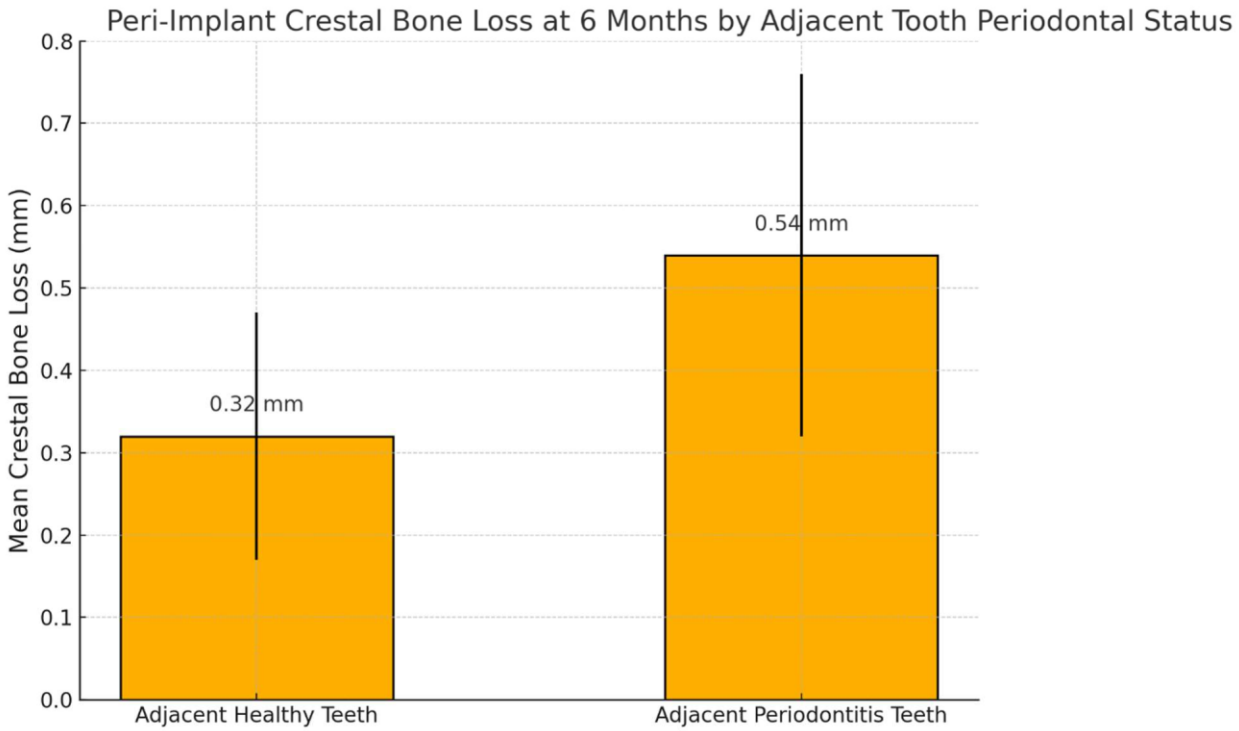

Figure 1: Mean PICBL (in millimeters) at 6 months post-implant placement, comparing implants adjacent to periodontally healthy teeth and those adjacent to periodontally compromised teeth. Error bars represent standard deviation. Implants adjacent to diseased teeth exhibited significantly greater bone loss ($p < 0.01$).

In this 6-month study of 48 implants, those adjacent to periodontally compromised teeth showed significantly greater crestal bone loss (0.54 mm) compared to implants next to healthy teeth (0.32 mm, $p< 0.01$). Periodontal parameters such as pocket depth and bleeding were worse in teeth adjacent to implants with higher bone loss. All implants remained stable with no failures, though mild mucositis was more common near diseased teeth. Multivariate analysis confirmed the periodontal status of adjacent teeth as a significant predictor of early peri-implant bone loss.

DISCUSSION

A prior study by Ravidà et al. [7] explored the relationship between periodontal disease and peri-implant bone loss, including both cross-sectional and retrospective studies. However, these studies have often been limited by their inability to capture temporal changes, making it difficult to establish causality. This study, through its longitudinal approach, offers a significant advantage by following patients over time, making its findings more reliable in determining causal relationships.

Previous studies, such as those by YOO H et al.[8], have established a general understanding that peri-implant bone loss is influenced by factors like implant placement protocols, patient health, and adjacent teeth status. This article aligns with those findings but specifically focuses on the periodontal status of adjacent teeth, providing new insights into how the health of surrounding teeth affects the early stages of bone resorption around implants. The result—significantly more bone loss in implants adjacent to periodontally compromised teeth (0.54 mm vs. 0.32 mm) reaffirms the connection between periodontal disease and peri-implant bone loss that has been previously observed in smaller or less controlled studies.

The study confirms earlier findings of Outatzis A et al. [9] that poor periodontal health around natural teeth is linked to

higher incidences of peri-implantitis and crestal bone loss. Parameters such as probing pocket depth and bleeding on probing were significantly worse in periodontally compromised teeth, further supporting the inflammatory pathway leading to peri-implant bone resorption. The observation that peri-implant mucositis was more frequent near diseased teeth also reinforces the findings of other studies that have suggested a higher risk of peri-implant inflammation in these situations.

Galindo-Moreno et al. [10] retrospective study in Clinical Implant Dentistry and Related Research aimed to establish an objective criterion for early marginal bone loss (MBL) to predict the prognosis of dental implants. The study analyzed data from 590 implants placed in 176 patients, focusing on radiographic MBL at loading, 6 months, and 18 months, alongside factors like age, gender, smoking habits, history of periodontitis, bone substrate, implant, and prosthetic features. The findings revealed that implants losing more than 0.5 mm of MBL within 6 months after loading were at significant risk of not being radiographically successful at 18 months. Additionally, a prosthetic abutment height of ≥2 mm was identified as the most protective factor for peri-implant bone maintenance. This study contributes to the ongoing discourse on defining success in implant dentistry by providing a quantifiable threshold for early MBL. While previous studies have established that MBL exceeding 2 mm at 1 year post-loading may indicate failure, this research offers a more immediate criterion, emphasizing the importance of early bone loss as a predictor of long-term implant success. Furthermore, the identification of abutment height as a protective factor adds a practical consideration for clinicians in optimizing implant outcomes.

Conclusion

In conclusion, the longitudinal study of PICBL in relation to the periodontal status of adjacent teeth highlights the significant influence of periodontal health on the stability of peri-implant bone. The findings indicate that implants placed adjacent to periodontally compromised teeth experience greater crestal bone loss compared to those adjacent to healthy teeth, underlining the importance of maintaining good periodontal health for optimal implant success.

The study's longitudinal design provides robust evidence that the periodontal condition of adjacent teeth plays a critical role in the progression of bone loss around implants over time. These results emphasize the need for comprehensive periodontal assessment and management prior to and following implant placement. By considering the periodontal health of neighboring teeth, clinicians can better predict and manage the risk of peri-implant bone loss, ultimately improving long-term implant outcomes. This study contributes to the growing body of evidence that underscores the interconnectedness of periodontal and implant health, guiding clinical decision-making for enhanced patient care in implant dentistry.

Conflicts of interest: Nil

Financial support: Nil

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