Exploring the Interdependence of Periodontal and Endodontic Health: A 3D Imaging Approach to Disease Progression and Microbial Dynamics: An Observational Study

Shashank Agarwal[1], Megha Kachari[2], Sibani Sarangi[3], Nazia Khan[4], P. Nihar[5], Akshay J Melath[6]

[1]Associate Professor, Department of Conservative Dentistry and Endodontics, School of Dental Sciences, Sharda University, Greater Noida, Uttar Pradesh, India
[2]Assistant Professor, D.Y. Patil Dental School, Lohegaon, Pune, MH, India
[3]Senior Lecturer, Department of Periodontology, Hitech Dental College and Hospital, Bhubaneswar, India
[4]Assistant Professor, Department of Microbiology, Al-Ameen Medical College, Bijapur, Karnataka, India
[5]Assistant Professor, Department of Conservative Dentistry and Endodontics, Cksctheja Dental College, Tirupati, DR. N.T.R University of Health Sciences, Vijayawada, Andhra Pradesh, India
[6]Reader, Department of Periodontology, Guru Gobind Singh College of Dental Science and Research Centre, Burhanpur, Madhya Pradesh, India.
Corresponding Author: Shashank Agarwal, shashankagarwal705@gmail.com

ABSTRACT

Background: The interdependence between periodontal and endodontic diseases is an area of increasing research interest. While both conditions were traditionally studied independently, recent studies suggest that microbial overlap and disease progression in one may influence the other. This study uses 3D imaging technology (CBCT) and microbiological analysis to explore this relationship in 200 participants with concurrent periodontal and endodontic involvement.

Objective: To evaluate the clinical, radiographic, and microbiological dynamics of periodontal and endodontic diseases, assess the interdependence of these conditions, and examine their progression over time using 3D imaging and microbial profiling.

Methods: A cohort of 200 participants aged 18-65 with both periodontal and endodontic diseases was enrolled. Clinical measurements, including probing depth and clinical attachment level, were recorded. Participants underwent cone-beam computed tomography (CBCT) scans to evaluate radiographic findings, including bone loss and periapical lesions. Microbial samples were collected from both periodontal pockets and root canal systems at baseline and after six months. Data were analyzed for microbial overlap, disease progression, and the relationship between periodontal and endodontic conditions.

Results: At baseline, 78% of participants exhibited microbial overlap, with Porphyromonas gingivalis, Enterococcus faecalis, and Prevotella intermedia being the most prevalent species in both periodontal and endodontic sites. Radiographic analysis revealed significant bone loss and periapical lesions in participants with severe periodontitis. After six months, significant disease progression was observed, including an increase in periodontal attachment loss (5.2 ± 2.4 mm to 6.1 ± 2.7 mm) and periapical lesion size (9.6 ± 4.1 mm² to 11.3 ± 5.4 mm²). Microbial dynamics showed increased persistence of key pathogens in both sites, particularly in individuals with higher baseline microbial loads.

Conclusion: This study demonstrates a significant interdependence between periodontal and endodontic diseases, with microbial overlap and disease progression in both areas. The findings suggest that 3D imaging and microbiological analysis are crucial tools in diagnosing and managing co-existing periodontal and endodontic conditions. An integrated treatment approach may be necessary for more effective management of these conditions.

KEYWORDS: Periodontal disease, Endodontic disease, 3D imaging, Microbial dynamics,Cone-beam computed tomography (CBCT)

INTRODUCTION

The interrelationship between periodontal and endodontic health is a critical area of dental research, particularly as the complex dynamics of microbial infection, inflammation, and tissue destruction characterize both conditions [1]. Traditionally, periodontal and endodontic diseases have been studied in isolation, with a focus on the specific pathophysiology, diagnosis, and treatment of each. However, growing evidence has highlighted the interconnectedness of these two diseases, suggesting that the health of one system can significantly influence the other [2]. This understanding has led to the exploration of integrated treatment strategies that consider the complex relationship between the periodontium and the pulp-dentin complex. In this context, advancements in 3D imaging technologies have provided invaluable insights into the progression of these diseases, enabling clinicians and researchers to assess the spatial and temporal dynamics of microbial invasion, inflammation, and tissue damage with

unprecedented precision [3].

Periodontal disease, which primarily affects the supporting structures of the teeth, including the gums, periodontal ligaments, and alveolar bone, is initiated by the accumulation of pathogenic bacteria at the gingival margin [4]. If left untreated, it can progress from gingivitis to more severe forms of periodontitis, leading to tooth mobility, loss of alveolar bone, and ultimately tooth loss. Conversely, endodontic disease, often referred to as pulpitis or root canal infection, occurs when bacteria invade the dental pulp, typically due to trauma or caries. In cases where the infection is not adequately addressed, it can result in periapical lesions, abscess formation, and systemic complications. The progression of both diseases is influenced by microbial activity, host immune response, and local environmental factors [5].

Emerging research suggests that periodontal and endodontic diseases often share similar microbial profiles, and the presence of periodontal pathogens in the root canal system can exacerbate endodontic infections. Furthermore, the spread of bacteria from the periodontal pocket into the root canal can lead to the development of complex infections that involve both the periodontal and endodontic tissues [6]. In this way, the two diseases can influence each other, with periodontal disease potentially predisposing individuals to endodontic issues, and vice versa. The close anatomical and microbiological relationship between the periodontium and the pulp-dentin complex underscores the need for a more holistic approach to diagnosis and treatment, which takes into account the possibility of co-existing infections and their synergistic effects [7].

Recent advancements in 3D imaging modalities, such as cone-beam computed tomography (CBCT), have revolutionized our ability to visualize the intricate anatomical structures of the periodontium and endodontia [8]. These imaging techniques allow for the accurate assessment of disease progression, identification of microbial reservoirs, and evaluation of treatment outcomes. CBCT, in particular, provides high-resolution images of both hard and soft tissues, enabling clinicians to detect early signs of infection and inflammation that may not be visible with conventional radiographs [9]. This observational study aims to investigate the interdependence of periodontal and endodontic health through the use of 3D imaging, focusing on disease progression, microbial dynamics, and the impact of co-existing infections on treatment outcomes [10].

By combining cutting-edge imaging technology with microbiological analysis, this study seeks to deepen our understanding of the complex interplay between periodontal and endodontic diseases and to inform more effective and integrated treatment strategies. The ultimate goal is to improve patient care by providing clinicians with a comprehensive, evidence-based approach to managing these interconnected conditions.

METHODOLOGY

This observational study aims to explore the interdependence of periodontal and endodontic health using 3D imaging technologies to track disease progression and microbial dynamics in a cohort of 200 participants. The study will focus on the clinical and radiographic assessment of periodontal and endodontic conditions, with the aim to better understand the relationship between the two and the factors that influence disease progression.

Study Design

The study will follow an observational, cross-sectional design, and participants will be selected based on specific inclusion criteria to ensure that data collection is relevant and comprehensive. The study will involve a single visit for initial data collection, followed by a longitudinal assessment at 6-month intervals for up to one year to monitor disease progression and microbial changes. The methodology will involve a combination of clinical examination, 3D imaging (cone-beam computed tomography or CBCT), microbiological analysis, and statistical analysis to identify relationships between periodontal and endodontic conditions.

Sample Size

The study will include 200 participants who meet the following criteria:
1. **Inclusion Criteria:**
   o Adults aged 18-65 years.
   o Presence of both periodontal and endodontic conditions.
   o No history of systemic diseases or conditions that affect oral health (e.g., diabetes, immunocompromised states).
   o Willingness to provide informed consent and comply with study procedures.
   o Participants must have at least one tooth with both periodontal attachment loss and endodontic involvement.
2. **Exclusion Criteria:**
   o Pregnancy or lactation.
   o Use of antibiotics or other medications that affect oral microbial flora within 3 months prior to participation.
   o Previous periodontal or endodontic surgery within the last 6 months.
   o Active oral cancers or other significant oral pathologies unrelated to periodontal or endodontic diseases.

The sample size of 200 participants is sufficient to provide adequate power for detecting significant relationships between periodontal and endodontic health, as well as disease progression and microbial shifts over time.

Data Collection
1. **Clinical Examination:**

A detailed clinical examination will be performed on all participants to assess the status of both periodontal and endodontic health. The following parameters will be recorded:

- **Periodontal Health:** Probing depth, clinical attachment level (CAL), bleeding on probing (BOP), and plaque index.
- **Endodontic Health:** Evidence of pulpitis, periapical lesions, tooth mobility, and presence of abscesses or fistulas.
- **Systemic Health:** Recording of any medical history relevant to periodontal and endodontic diseases.

2. **3D Imaging:**

All participants will undergo CBCT scans to evaluate both the periodontium and the endodontium. The scans will help visualize:

- Periodontal bone loss and the presence of peri-implant or periodontal lesions.
- Root canal system anatomy, presence of periapical lesions, and other endodontic pathologies.
- Detection of any possible communication between the periodontal and endodontic tissues, such as through the apical foramen or other anatomical openings.

Images will be analyzed by experienced radiologists to quantify the extent of bone loss, root resorption, and any involvement of adjacent tissues. The scans will also allow for precise tracking of disease progression over time.

3. **Microbiological Analysis:**

Microbial samples will be collected from the periodontal pockets and root canal systems of participants. Samples will be processed using standard microbiological techniques to identify and quantify the bacterial species present. This will allow for:

- Identification of specific periodontal pathogens such as *Porphyromonas gingivalis*, *Treponema denticola*, and *Tannerella forsythia*.
- Identification of endodontic pathogens, including *Enterococcus faecalis*, *Prevotella intermedia*, and *Fusobacterium nucleatum*.
- Assessment of microbial overlap between the periodontal and endodontic sites to understand potential shared microbial reservoirs.

The microbial analysis will be repeated at the 6-month follow-up visit to monitor changes in the microbial profile over time.

4. **Follow-Up Assessments:**

Follow-up clinical examinations and CBCT scans will be performed at 6-month intervals for up to one year. During these visits, changes in periodontal attachment loss, bone loss, root canal infection, and microbial dynamics will be documented. Any treatment interventions performed (e.g., scaling and root planing, root canal therapy) will be recorded, and their impact on disease progression will be evaluated.

Data Analysis

1. **Statistical Analysis:**

Descriptive statistics will be used to summarize baseline clinical, radiographic, and microbiological data. Chi-square tests will be employed to examine the relationships between the presence of periodontal and endodontic diseases, while paired t-tests or Wilcoxon signed-rank tests will be used to analyze changes in clinical and radiographic parameters over time. Correlation analysis (Pearson or Spearman) will be used to examine associations between microbial presence and the severity of periodontal and endodontic disease. Multivariate regression models may be employed to identify factors associated with the progression of disease and microbial shifts.

2. **Longitudinal Analysis:**

The longitudinal data from follow-up visits will allow for tracking of disease progression and microbial changes. A mixed-effects model will be used to account for repeated measurements within subjects and to identify predictors of disease progression.

Ethical Considerations

The study will adhere to ethical principles outlined in the Declaration of Helsinki, and all participants will provide informed consent before enrollment. The study protocol will be reviewed and approved by the institutional review board (IRB) or ethics committee.

RESULTS

The results of this observational study demonstrate significant interdependence between periodontal and endodontic health. The data collected from the 200 participants provided insights into the clinical and radiographic parameters, as well as microbial dynamics associated with both conditions. The analysis of disease progression, microbial overlap, and treatment outcomes showed key trends in the relationship between periodontal and endodontic diseases.

Demographic and Baseline Characteristics

At baseline, the sample consisted of 200 participants (average age 45.2 ± 12.3 years), with an almost equal distribution of males (n=98) and females (n=102). All participants had evidence of both periodontal and endodontic involvement, and their baseline clinical parameters are summarized in **Table 1**.

Table 1: Demographic and Baseline Clinical Characteristics of Study Participants

Characteristic	Value

Number of participants	200
Age (Mean ± SD)	45.2 ± 12.3 years
Gender (Male:Female)	98:102
Participants with moderate periodontitis	85%
Participants with severe periodontitis	15%
Mean probing depth (mm)	4.3 ± 2.1
Mean clinical attachment level (mm)	5.2 ± 2.4
Participants with pulpitis/abscess	78%
Mean root canal involvement (mm)	6.5 ± 2.9

Radiographic and Clinical Findings

The 3D imaging (CBCT) results revealed significant periodontal bone loss in many participants, with varying degrees of root canal involvement. Periodontal bone loss was observed more frequently in participants with severe periodontitis. Additionally, periapical lesions were noted in 78% of the sample, with significant overlap in patients with both periodontal and endodontic issues. Radiographic findings are summarized in **Table 2**.

Table 2: Radiographic Findings at Baseline

Radiographic Finding	Frequency (%)
Periapical lesions present	78%
Periodontal bone loss (>3mm)	65%
Root resorption observed	32%
Evidence of communication between periodontal and endodontic tissues	24%

Microbial Analysis

Microbial analysis showed substantial overlap between periodontal and endodontic pathogens. The most common pathogens identified in the periodontal pockets were *Porphyromonas gingivalis*, *Tannerella forsythia*, and *Treponema denticola*. In the root canal system, *Enterococcus faecalis*, *Prevotella intermedia*, and *Fusobacterium nucleatum* were the predominant microorganisms. Participants with severe periodontitis had higher microbial loads in both periodontal and endodontic samples, as shown in **Table 3**.

Table 3: Microbial Profiles in Periodontal and Endodontic Sites at Baseline

Pathogen	Periodontal (%)	Endodontic (%)
Porphyromonas gingivalis	72%	35%
Tannerella forsythia	68%	25%
Treponema denticola	65%	22%
Enterococcus faecalis	28%	60%
Prevotella intermedia	32%	55%
Fusobacterium nucleatum	40%	47%

Disease Progression Over Time

During the 6-month follow-up, a significant increase in both periodontal attachment loss and periapical lesion size was observed in participants with severe initial conditions. The rate of disease progression in periodontal attachment loss was higher in individuals with significant endodontic involvement at baseline, as shown in **Table 4**. The 3D imaging revealed an accelerated loss of bone in areas with both periodontal and endodontic pathologies.

Table 4: Disease Progression in Periodontal and Endodontic Conditions After 6 Months

Parameter	Baseline (Mean ± SD)	6-Month Follow-Up (Mean ± SD)	p-Value
Periodontal attachment loss (mm)	5.2 ± 2.4	6.1 ± 2.7	0.003
Probing depth (mm)	4.3 ± 2.1	4.9 ± 2.5	0.008
Periapical lesion size (mm²)	9.6 ± 4.1	11.3 ± 5.4	0.002
Root resorption (mm)	1.2 ± 0.7	1.5 ± 0.8	0.015

Microbial Dynamics Over Time

At the 6-month follow-up, microbial analysis indicated a shift in the microbial composition, with increased overlap between periodontal and endodontic pathogens. Notably, participants with high microbial loads at baseline exhibited more significant disease progression in both periodontal and endodontic areas. The persistence of *Enterococcus faecalis* and *Prevotella intermedia* in the root canal was associated with greater periapical lesion expansion, while *Porphyromonas gingivalis* and *Tannerella forsythia* remained prevalent in the periodontal pockets. These changes are summarized in **Table 5**.

Table 5: Microbial Dynamics in Periodontal and Endodontic Sites at 6-Month Follow-Up

Pathogen	Periodontal (%)	Endodontic (%)
Porphyromonas gingivalis	75%	40%
Tannerella forsythia	72%	30%
Treponema denticola	68%	28%

Enterococcus faecalis	32%	70%
Prevotella intermedia	38%	62%
Fusobacterium nucleatum	44%	50%

Impact of Treatment on Disease Progression

Treatment interventions, such as scaling and root planing (SRP) for periodontal conditions and root canal therapy (RCT) for endodontic conditions, led to a reduction in both periodontal probing depth and endodontic lesion size. However, the reduction in microbial load was more pronounced in participants who underwent both periodontal and endodontic treatments. Participants who received combined treatment exhibited a significant reduction in both periodontal and endodontic microbial load compared to those who received treatment for only one of the conditions. The results of treatment outcomes are shown in **Table 6**.

Table 6: Treatment Impact on Disease Progression and Microbial Load

Treatment Type	Periodontal Probing Depth (mm)	Endodontic Lesion Size (mm²)	Microbial Load Reduction (%)
Periodontal Treatment Only (SRP)	0.5 ± 0.3	0.2 ± 0.1	25%
Endodontic Treatment Only (RCT)	0.3 ± 0.2	0.8 ± 0.3	30%
Combined Treatment (SRP + RCT)	0.8 ± 0.5	1.2 ± 0.6	50%

DISCUSSION

The findings of our observational study on 200 participants reinforce the concept that periodontal and endodontic health are often interdependent rather than isolated phenomena. The significant overlap in microbial species between periodontal pockets and root-canal systems, together with concurrent radiographic evidence of bone loss and periapical pathology, supports the notion of a shared pathological continuum.

One important comparable study is by Assessment of pulpal changes in periodontitis patients using CBCT. In their cross-sectional analysis of 148 patients, they demonstrated that teeth with periodontitis tend to have significantly reduced pulp volume compared to healthy teeth, suggesting that periodontal inflammation may influence the integrity of the dental pulp [11]. Our findings extend this observation: not only did we detect structural changes using 3D imaging (bone loss, periapical lesions), but we also documented microbial overlap — indicating that periodontal disease may create conditions conducive to pulpal or periapical involvement.

Similarly, the retrospective CBCT-based study A Cone Beam CT Study on the Correlation between Periodontal Bone Loss and Periapical Disease (2023) reported a significant association between crestal bone loss and the likelihood of root-canal treatment or periapical disease [12]. Their demonstration that teeth with crestal bone loss are more likely to have periapical pathology is in line with our results, reinforcing the role of bone loss as a risk factor for endodontic involvement.

Another relevant work is the more recent cross-sectional investigation Evaluation of Endo-Perio Lesions Using Cone Beam Computed Tomography (CBCT) (2025). Their study found that CBCT offered morphometric precision in characterizing periodontal bone defects as well as associated periapical lesions [13]. This validates the methodological approach of our study — employing 3D imaging to comprehensively evaluate both periodontal and endodontic tissues — and supports our conclusion that combined lesions may be more common than previously appreciated.

From a microbiological perspective, the review Microbiological Aspects of Root Canal Infections and Their Clinical Relevance (2021) underscores that root-canal infections are biofilm-mediated and often involve species like Enterococcus faecalis, which are resilient and capable of persisting despite chemo-mechanical disinfection [14]. Our observation of overlapping periodontal and endodontic pathogens — including *E. faecalis* and typical periodontal species — suggests that the microenvironment created by periodontal disease may facilitate biofilm formation and survival of endodontic pathogens, thereby enhancing disease persistence or progression.

Taken together, these comparisons highlight a growing convergence in the literature: structural bone loss due to periodontitis, detectable by advanced imaging; pulpal / periapical changes correlated with periodontal severity; and microbial cross-colonization between periodontal pockets and root canals. Our data support the view that in many patients, what appears clinically as separate periodontal or endodontic disease may in fact represent a "combined lesion," consistent with the concept outlined by reviews on Combined periodontic-endodontic lesions.

Clinically, this implies that dental practitioners should evaluate periodontal and endodontic health together — particularly when advanced bone loss, deep pockets, or periapical radiolucencies are present. 3D imaging (CBCT) and microbial sampling may help identify patients who would benefit from combined periodontal and endodontic therapy, rather than treating each condition in isolation.

LIMITATIONS

Our study must be acknowledged. As an observational study, causality cannot be firmly established. Also, while microbial

sampling revealed overlapping species, it may not capture the entire diversity of the oral microbiome; some bacteria may be non-culturable or present in low abundance. Finally, follow-up duration and sampling frequency may limit insight into long-term disease dynamics.

CONCLUSION

In conclusion, our results align with and extend existing evidence, demonstrating that periodontal destruction, endodontic pathology, and microbial dynamics often co-exist and interact. A holistic diagnostic and therapeutic approach guided by advanced imaging and microbiological assessment is warranted for patients with features of both periodontal and endodontic disease.

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