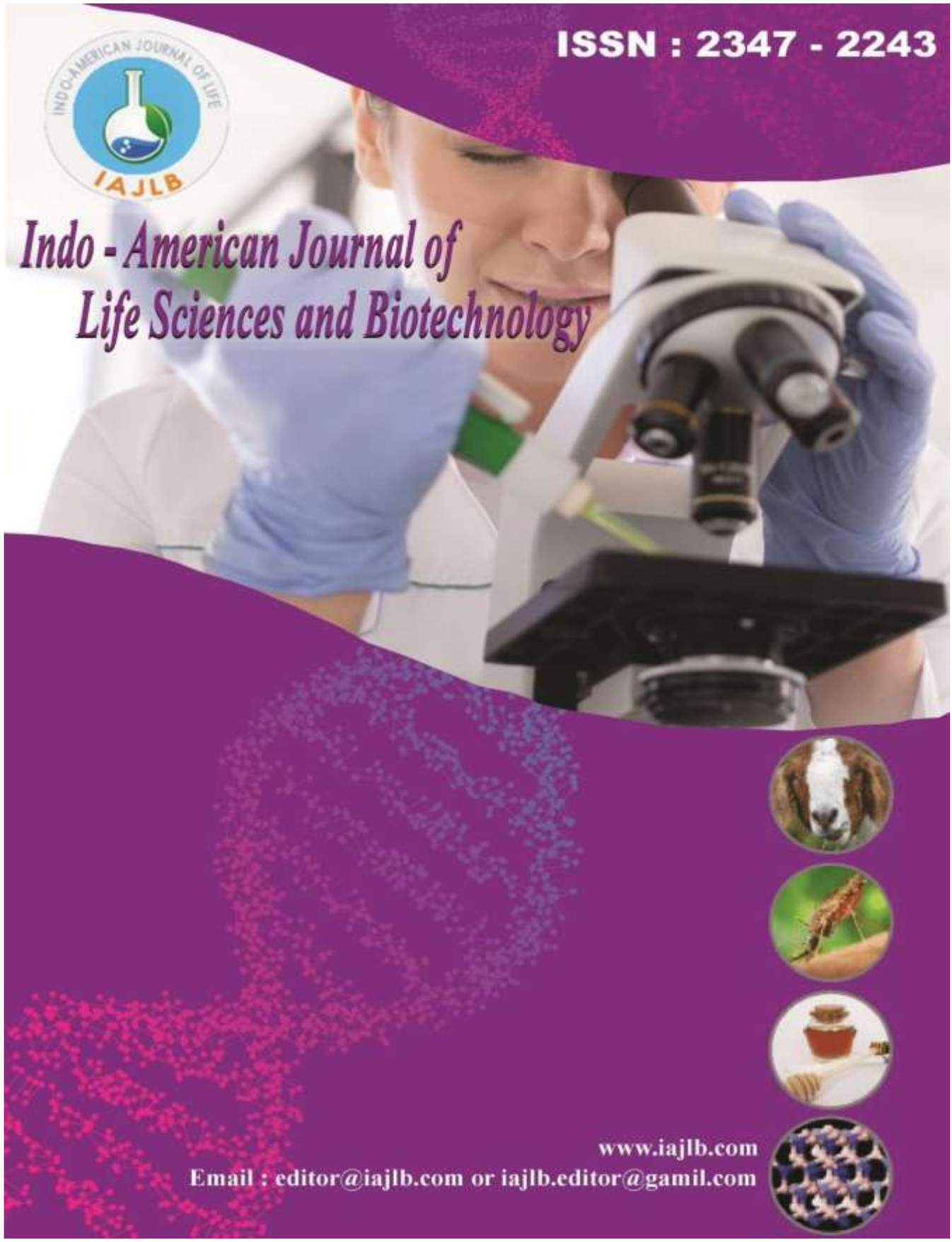
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Indo-Am. J. of Life Sc & Bt.2026 *ISSN 2347-2243 www.iajlb.com*
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Clinical Evaluation of Secondary Endodontic Infection and Pulp Necrosis in Teeth Restored with Crown Restoration without Prior Root Canal Therapy

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ABSTRACT

Background: Vital pulp crown restorations can result in pulpal necrosis and secondary endodontic infection which can be clinically undetectable.

Objective: The frequency of pulp necrosis and secondary endodontic infections in vital pulp crowned teeth without a previous endodontic procedure was assessed. Clinical and radiological conditions were also assessed.

Methods: A cross-sectional study was carried out on 150 patients aged between 25-40 years, whose permanent teeth were crowned and placed without an endodontic procedure. Systematic random sampling was used to select the study participants. The collected data were analyzed by both descriptive and analytical statistics. Pulp testing was done by Endo-Ice®, Electric Pulp Tester, pain/tenderness to percussion, palpation tests and radiographs. Data such as type of crown, time of restoration, tooth concerned, symptoms, palpability of the pulp, and radiographic assessment of the periapical region were collected.

Results: Evaluated crowned teeth also showed evidence of necrosis of the pulp and infection of the endodontic system clinically and radiologically. It was noted that pulp necrosis occurred in restoration time of more than 2 years and was evident in the presence of pain, tenderness to percussion and periapical radiographic findings.

Conclusion: Teeth crowned without prior endodontic access demonstrated pulpal necrosis and endodontic infection clinically, and the crowned teeth were analyzed radiologically, The necrosis of the pulp was demonstrated by loss of sensitivity to pulp. The clinically evident pulpal necrosis and infection can be managed and diagnosed through routine postoperative assessments that include restoration time, clinical and radiological examinations and palpation tests.

Keywords: Endodontics, Crown, Restoration, Pulp, Root Canal.

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Vol.23, Issue 3, 2026

Indo-American Journal of Life Sciences and Biotechnology

INTRODUCTION

Full coverage crown restorations provide both structural integrity and cosmetic restorations for permanently damaged teeth. If the dental pulp is healthy, clinically, placing a crown is often done to avoid a root canal. This is to protect the vitality of the living tooth. Paradoxically, crown placements are considered indirect restorations. Therefore, the placement of a crown on an untreated tooth endodontically should account for the biological nature of the pulp and the potential threats from mechanical, thermal, chemical, and bacterial sources associated with the placement procedure (1).

New clinical data suggests that some teeth capped with full-coverage crowns experience pulpal and periapical disease development. An experiment evaluated vital teeth before and after crown placement by assessing the teeth both clinically and radiographically before and after crown preparation and placement. For this experiment, the electric pulp test was performed at different stages. This study described the development of pulpal and periapical pathoses after crown placement. It reported the exposure of the pulp during crown preparation and the preoperative bone level as decreased (2).

The last few years have also seen a call for expanding the knowledge base on indirect restorations, since restorations with indirect restorations also involve biological challenges. One systematic review combined with meta-analysis from 2023 included 37 clinical studies. It determined a pooled rate of 5.02% for pulp necrosis and 3.63% for periapical pathosis as a result of indirect restorations. The authors investigated the influence of a variety of clinical, operational, and control factors on the outcome of pulp restorations such as length of time between interim restoration placement and crown cementation, and clinical follow-up duration (1).

The state of the pulp prior to restorative procedures takes on added significance since procedures can further affect the pulp and ultimately create a situation of pulpal pathology even when the tooth is initially asymptomatic. Recent evidence cites the planning of indirect restorations, as well as the restorative procedures, as requiring assessment of the remaining tooth structure and the state of the pulp (3). The indirect restorations typically require more than one appointment; therefore the length of the indirect restoration is also a consideration, since treatment-related issues may become evident during the follow-up period.

A 2024 systematic review and meta-analysis investigated direct and indirect posterior composite restorations. Time was a factor in restoration failure, and failure was attributed to fractures, chipping, and caries. The reviewed literature was primarily concerned with restoration survival, as opposed to the development of pulpal disease, however the authors of the review emphasize the need for long-term monitoring for indirect restorations (4).

Contemporary restorative techniques may have an impact on the biology at the restoration-tooth interface. The sealing of dentin and the interaction of prepared dentin with the restoration are of interest when considering the clinical viability of an indirect restoration. The literature on the placement of indirect restorations on vital teeth has emphasized the role of sealing the new dentin (5).

When considering crowned teeth, although there may be no clinical signs of pulpal involvement, it is vital that the status of the pulpal tissue be known. In endodontic treatment, cold tests and electric pulp tests are standard sensibility tests. A recent systematic review and meta-analysis examining pulp vitality and sensibility tests noted that pulse oximetry was more accurate than electric pulp stimulation and traditional cold tests, andalso that the usual

Indo-Am. J. of Life Sc & Bt.2026 *ISSN 2347-2243 www.iajlb.com*
Vol.23, Issue 3, 2026

Indo-American Journal of Life Sciences and Biotechnology

sensibility tests are needed when interpreting the results clinically for pulpal evaluation (6).

Evidence-based literature has discussed the utility of cold testing in diagnostics. A 2022 review of diagnostic accuracy studies analyzed cold, heat, and electric pulp testing in the context of methods designed to assess pulp vitality. It was reported that the limitations of conventional testing are related to the assessment of neural responses and not the direct blood supply of the pulp. Thus, the clinical assessment requires integration of the patient's signs and symptoms, in addition to the test findings and other diagnostic data (7).

Although its use remains justified when performed adequately, electric pulp testing remains a clinical diagnostic method. A 2023 cross-sectional study reported on the effects of EPT on premolar and molar teeth. It reported on the response time and pain threshold of the teeth and indicated the importance of the testing site and the characteristics of the tooth structure. These findings suggest that the use of EPT in diagnostics is justified when standardized testing is implemented (8).

Clinical research done recently compared traditional pulp sensitivity testing with new diagnostic methods. A 2023 study, which was a crossover design, included 480 teeth where a new electronic pulp sensitivity testing device was used in addition to the cold and electrical pulp sensitivity testing devices. It was reported that a significant proportion of teeth responded differently to different testing methods, and the traditional methods remain important for clinical assessment of the pulp (9).

Research related to pulp diagnosis continues to develop to create more indirect methods of assessing pulp vitality. One such method is optical scanning of pulp. A clinical study published in 2024 evaluated this novel scanning method in 421 emergency cases and compared the scanning results to traditional diagnostic techniques and cold pulp tests. Though the authors note the examinations limitations, the study illustrated the valuable contribution this technology has for the assessment of pulp vitality (10).

The effect of the restorative procedure on the pulpal response must also be considered for teeth that suffer significant structural loss. Regarding restorative procedures on structurally compromised teeth, where direct or indirect restorations are considered, recent systematic evidence states that the restoration may be determined by the remaining tooth structure, the magnitude and extent of the defect, as well as other clinical considerations. This further indicates that a full-coverage restoration on a vital tooth should be undertaken after a thorough diagnostic evaluation (11).

Current endodontic literature concurs that giving a diagnosis requires considering numerous factors. In the absence of a truthful response to a cold test, interpretation of the results of pulp sensitivity must include subjective signs, symptoms, palpation, percussion, clinical examination, and radiography. Recent studies on the diagnostic evaluation of pulpal status have noted that integration of clinical findings amplifies the reliability of the diagnostic evaluation beyond the scope of a single test (12).

Current studies are limited evaluating post crown placement secondary endodontic infections and permanent teeth with pulp necrosis. Recent studies have examined indirect restorations as a broad category, temporary crowned vital teeth, and the diagnostic accuracy of the pulp testing methods. Given the differences in study criteria, the assessment of crowned teeth conducted in routine practice justifies further clinical studies (13).

Assessing permanent teeth crowned without previous root canal therapy helps to

Indo-Am. J. of Life Sc & Bt.2026 *ISSN 2347-2243 www.iajlb.com*
Vol.23, Issue 3, 2026

Indo-American Journal of Life Sciences and Biotechnology

determine which teeth have developed loss of pulp vitality or secondary endodontic infection. The early detection of pulpal and periapical pathosis may be achieved with a diagnostic evaluation based on case history, clinical exam, cold and electric pulp testing, percussion, palpation, and a periapical radiographic examination. The purpose of this study was to clinically assess permanent teeth crowned without root canal therapy to determine the presence of secondary endodontic infection and pulp necrosis and to assess the clinical and radiographic factors associated with these conditions (1).

METHODOLOGY

Study Design and Setting

A descriptive cross-sectional clinical study was designed to analyze the occurrence of secondary endodontic infection and pulp necrosis on permanent teeth restored with crown restorations performed without prior root canal therapy. The study was undertaken to ascertain the prevalence of such complications in the Department of Operative Dentistry/Restorative Dentistry at a tertiary care dental hospital during a period of six months.

Study Population

The study population consisted of patients harboring permanent teeth restored with full-coverage crowns devoid of root canal therapy. The age range of the participants was kept between 25 years and 40 years.

Sample Size and Sampling Technique

In this study, 150 participants were included. They were selected by a method of systematic random sampling technique Participants were chosen at a given sampling interval until the required sample number was reached following the inclusions and exclusions criteria.

Inclusion Criteria

Participants were included if they were between 25 and 40 years of age and hosted at least one permanent tooth restored with a full-coverage crown with no root canal therapy. The teeth that had restorations that the researcher could access and had sufficient tooth structure were included. Participants were also included if they could participate in the assessment of pulpal sensibility and radiographic assessments.

Exclusion Criteria

Evaluated teeth that received a root canal, had sustained traumatic injury, had severe periodontal disease, had an unrestored crown that made assessment unreliable, or had poor clinical and radiographic records were also excluded. Additionally, patients who were unable to provide reliable clinical information and failed to complete an examination were excluded.

Data Collection procedure

Data were collected using a researcher designed and developed clinical examination proforma. The proforma contained sections for demographic data, description of the tooth, crown restoration data, restoration time, and presentation description. The data included the patient's age, gender, tooth, type of crown, restoration time, postoperative pain, pain on biting, type of pain, and history of pain.
Pulp sensibility was evaluated using Endo-Ice® Cold Pulp Testing, a cold test based on refrigerants for evaluating the pulpal sensory response. The assessment of the cold test recorded the response of the patient to the application of the stimulus.
The standardization of pulp sensibility assessment utilized an Electric Pulp Tester (EPT). The EPT assessment documented whether the tooth generated a sensory response to the stimulus. Instructions to the manufacturer of the device were followed.

Indo-Am. J. of Life Sc & Bt.2026 *ISSN 2347-2243 www.iajlb.com*
Vol.23, Issue 3, 2026

Indo-American Journal of Life Sciences and Biotechnology

Clinical evidence of periapical inflammation was evaluated through percussion and palpation tests. Percussion was documented as positive or negative, depending on the presence or absence of tenderness, respectively. Palpation was documented as positive or negative, depending on the patient's response to pressure applied on the periapical region.
Assessment of periapical inflammation was performed using intraoral periapical radiographs. The radiograph assessment documented the presence and the degree of radiolucency of the periapical region, widening of the periodontal ligament (PDL), loss of lamina dura, and any other abnormal periapical structures.

Clinical Assessment Procedure
Prior to the standardized clinical examination, informed consent was obtained from each participant. The clinical examination proforma was used to collect the participant's demographic information and dental history. The crowned tooth was examined for restoration, presence of any defect, tenderness, and other clinical findings.
Pulp sensibility testing was done after isolation of the involved tooth. For cold testing, Endo-Ice® was used and noted the patient's response. This response was compared to an appropriate control tooth whenever necessary. Then performed an electric pulp test and recorded whether the response was positive or negative. Percussion and palpation were done next in order to find clinical symptoms of periapical inflammation.
A periapical intraoral radiograph was taken for each tooth after standardized irradiation. Radiograph was evaluated for periapical radiolucency and for other signs of periapical inflammation such as widening of the periodontal ligament space, loss of lamina dura, etc., and looked for all of the above clinical and radiological findings to determine the state of the pulp and periapex of each tooth.

Assessment of Pulpal and Endodontic Status
To determine the status of the pulp, Patient's symptoms, the findings of the cold pulp test and of the electric pulp test, the findings of palpation and percussion, and the radiographs were evaluated. It was assumed the presence of suspected or confirmed necrosis of the pulp in the damaged teeth which showed no response to testing of pulp sensation and which showed compatible clinical or radiographic signs.
It was assumed there was a case of secondary endodontic infection in a crowned tooth that was previously untreated in which the signs of endodontic infection were present with loss of pulp vitality and periapical inflammatory changes with radiolucent periapex, widened periodontal ligament and absence of lamina dura.

Study Variables
The primary outcome variables were pulp necrosis and secondary endodontic infection. The independent variables were age, gender, tooth location, type of crown restoration, duration of crown placement, postoperative pain, spontaneous pain, pain on biting, cold pulp test response, EPT response, percussion findings, palpation findings, and radiographic periapical status.

Data Quality and Reliability
Prior to the formal start of data collection, the researcher standardized the clinical examination and data recording. The researcher was trained on how to appropriately perform and interpret cold pulp testing, EPT, percussion, palpation, and assessment of periapical radiographs. A preliminary assessment was performed on some of the eligible cases to ensure that the

Indo-Am. J. of Life Sc & Bt.2026 *ISSN 2347-2243 www.iajlb.com*
Vol.23, Issue 3, 2026

Indo-American Journal of Life Sciences and Biotechnology

examination procedure and the data collection proforma were understood and performed in a standardized and consistent manner. This standardized procedure was maintained throughout the study to minimize measurement variability.

Data Analysis

The data were entered and analyzed using SPSS version 26.0. Categorical variables were summarized using frequencies and percentages. The relationship between the categorical variables (duration of crown restoration, pulp status, and periapical status) was analyzed using the Chi-square test. A p value of less than 0.05 was considered statistically significant.

Ethical Considerations

Before starting the research, All concerned participants were informed of the experimental process and the study objectives to which they provided their consent. They were free to withdraw from the study any time they wished. Research data were collected and stored in a safe location as promised and participant demographic data and information on clinical status was maintained confidential. The data collected were only used in research.

RESULTS

Table 1. Socio-Demographic Characteristics of Participants (N = 150)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	25–29	38	25.3
	30–34	51	34.0
	35–40	61	40.7
Gender	Male	78	52.0
	Female	72	48.0
Residence	Urban	96	64.0
	Rural	54	36.0
Total		150	100.0

Most study subjects were between 35 and 40 years old (40.7%) with 52.0% being males.

Table 2. Clinical Characteristics of Crown-Restored Teeth (N = 150)

Variable	Category	Frequency (n)	Percentage (%)
Type of crown	Porcelain-fused-to-metal	67	44.7
	Zirconia	49	32.7
	All-ceramic	34	22.7
Tooth involved	Maxillary anterior	29	19.3
	Maxillary posterior	42	28.0
	Mandibular anterior	18	12.0
	Mandibular posterior	61	40.7
Duration of crown	<2 years	43	28.7
	2–5 years	58	38.7
	>5 years	49	32.7

Indo-Am. J. of Life Sc & Bt.2026 *ISSN 2347-2243 www.iajlb.com*
Vol.23, Issue 3, 2026

Indo-American Journal of Life Sciences and Biotechnology

Previous postoperative pain	Yes	41	27.3
	No	109	72.7

Porcelain-fused-to-metal crowns were the most common restoration (44.7%) and mandibular posterior teeth were the largest tooth group (40.7%).

Table 3. Clinical and Pulp Sensibility Findings (N = 150)

Clinical Finding	**Category**	**Frequency (n)**	**Percentage (%)**
Cold pulp test	Positive	113	75.3
	Negative	37	24.7
Electric pulp test	Positive	110	73.3
	Negative	40	26.7
Percussion test	Negative	118	78.7
	Positive	32	21.3
Palpation test	Negative	128	85.3
	Positive	22	14.7
Spontaneous pain	Present	19	12.7
	Absent	131	87.3
Pain on biting	Present	27	18.0
	Absent	123	82.0

Negative pulp sensibility responses were noted in 24.7% of the teeth by cold testing and in 26.7 % of the teeth by electric pulp testing.

Table 4. Radiographic Findings of Crown-Restored Teeth (N = 150)

Radiographic Finding	**Category**	**Frequency (n)**	**Percentage (%)**
Periapical radiolucency	Present	28	18.7
	Absent	122	81.3
PDL widening	Present	34	22.7
	Absent	116	77.3
Loss of lamina dura	Present	21	14.0
	Absent	129	86.0
Periapical status	Normal	119	79.3
	Abnormal	31	20.7

Periapical radioluceny was noted in 18.7 % of the teeth that were assessed and abnormal overall periapical status was noted in 20.7 %.

Table 5. Frequency of Pulpal and Endodontic Outcomes (N = 150)

Outcome	**Frequency (n)**	**Percentage (%)**
Normal pulp/vital response	110	73.3
Suspected pulp necrosis	28	18.7

Indo-Am. J. of Life Sc & Bt.2026 *ISSN 2347-2243 www.iajlb.com*
Vol.23, Issue 3, 2026

Indo-American Journal of Life Sciences and Biotechnology

Confirmed pulp necrosis with periapical changes	12	8.0
Total	150	100.0

Pulp necrosis or loss of pulp vitality was noted in the crowned teeth. Secondary endodontic infection was noted in 20.7 %.

Combined Clinical Classification

Combined Clinical Classification	**Frequency (n)**	**Percentage (%)**
No evidence of secondary endodontic infection	119	79.3
Secondary endodontic infection	31	20.7
Total	150	100.0

Table 6. Association Between Duration of Crown Restoration and Pulp Necrosis

Duration of Crown	**Pulp Vitality n (%)**	**Pulp Necrosis n (%)**	**Total**	**χ^2**	**p-value**
<2 years	38 (88.4)	5 (11.6)	43		
2–5 years	44 (75.9)	14 (24.1)	58		
>5 years	28 (57.1)	21 (42.9)	49	13.84	0.001
Total	110 (73.3)	40 (26.7)	150		

From the combined assessment, a slightly longer crown and pulp necrosis was noted in teeth clinically restored for five years or longer ($\chi^2 = 13.84$, $p = 0.001$).

Table 7. Association between Periapical Status and Pulp Vitality

Pulp Status	**Normal Periapical Status n (%)**	**Abnormal Periapical Status n (%)**	**Total**	**χ^2**	**p-value**
Vital pulp	104 (94.5)	6 (5.5)	110		
Necrotic pulp	15 (37.5)	25 (62.5)	40	52.91	<0.001
Total	119 (79.3)	31 (20.7)	150		

Abnormal periapical findings were significantly higher in teeth with necrotic pulp than in teeth with a vital pulp ($\chi^2 = 52.91$, $p < 0.001$).
Note. Frequency (n) and percentage (%) are presented. χ^2 = chi-square test.

DISCUSSION

This study investigated crown-restored permanent teeth to analyze instances of pulp necrosis and secondary endodontic infection. Based on the findings of the study, there was a 26.7% loss of pulp vitality in the studied sample. Additionally, 20.7% of the sample had secondary endodontic infection based on clinical and radiological assessments. In light of the findings of this study, pulpal complications strengthen the need for continuous

Indo-Am. J. of Life Sc & Bt.2026 *ISSN 2347-2243 www.iajlb.com*
Vol.23, Issue 3, 2026

Indo-American Journal of Life Sciences and Biotechnology

monitoring of restored permanent teeth without prior endodontic procedures.

Pulp necrosis was related to the duration of crown restoration, because more pulp necrosis occurred in teeth that were crown restored for over 5 years. The reason may be that factors in crown restorations, bacterial leakage, and changes to the structure, along with the slow deterioration of the pulp, occur over the years. Similar findings in the literature show that for crown restorations, there are pros and cons to the adverse outcomes to the restorations that depend on the vitality of the tooth and other clinical factors. This shows that it's important to study crown restorations over long periods (14).

The present study also reveals an association between pulp necrosis and periapical status. Of the teeth that were necrotic, a high percentage of the teeth had an abnormal periapical status when compared to teeth that had a pulp status of normal. This finding is expected as loss of vitality of the pulp supports the growth of microorganisms and the inflammation of the tissues. In the field of endodontics, it is especially related to other clinical considerations to access the biological status of a tooth (15). Negative responses to the pulp testing were observed in a relatively high percentage of the crowned teeth in the present study. The use of both tests was valuable since diagnostic information regarding the pulp was complemented with the use of a different diagnostic test.

Current clinical studies have shown that cold and electric pulp testing differ in their diagnostic value and that a combination of their tests improves clinical diagnostic decision making. This is also the case in the current study, where cold and EPT testing was done in combination with symptoms and other clinical signs (16).

Periapical radiographs showed periapical radiolucency and increased periodontal ligament space. These findings were seen in some crowned teeth. Radiographs were useful in these cases where the clinical signs were non-existent or slight. It was also found that clinical pulp testing, by itself, neglected to evaluate the overall endodontic status of the tooth. The focus in many recent studies has been on the importance of the combination of pulp sensibility testing and clinical and radiographic assessment as opposed to an isolated diagnostic finding (17).

The use of infrared stimulation for standardized pulp testing has also been studied. A crossover study used 480 teeth and found that, when compared to a newer electronic pulp sensitivity device, conventional cold and electric pulp testing produced a high proportion of positive responses and was a positive reference method. These findings also support the routine use of cold and electric pulp testing where their results are interpreted along with symptoms, percussion and palpation and radiographic examinations (9).

The results of this study indicate that patients should be aware that restorations without the use of endodontic therapy could still result in complications of the pulp and/or periapical tissues. Longer crown restorations appear to increase the likelihood of pulp necrosis, indicating that older restorations should even be of some concern. Pulp necrosis and the presence of periapical pathosis should be diagnosed in the clinical context of a perceived loss of sensibility of the affected tooth and supported by clinical and radiographic investigations. The findings of this study support the recommended conservative approach to crown therapy, which is to undertake root canal therapy only where clinically indicated based on the patient's complaint and supported by clinical and radiographic evidence of a change in the vitality of the affected tooth.

Indo-Am. J. of Life Sc & Bt.2026 *ISSN 2347-2243 www.iajlb.com*
Vol.23, Issue 3, 2026

Indo-American Journal of Life Sciences and Biotechnology

CONCLUSION

The results of this study indicate that clinically relevant cases of pulp necrosis and associated secondary endodontic infection were presented in teeth restored with crowns, and in the absence of prior root canal therapy. Longer crown restorations were significantly associated with pulp necrosis, and pathotic periapical changes were significantly associated with necrotic pulps. The results of this study confirmed the importance of an appropriate clinical and radiographic assessment for the early identification of periapical and pulpal pathosis.

Future Suggestions

Future studies should include crown restorations from multiple dental clinics, and should expand the duration of follow-up to assess the long-term results. The results of this study may be expanded with additional studies incorporating root canal therapy on teeth with pathotic periapical changes and restorations place with modern crown technology, assessed with modern methods of pulp assessment and with an evaluation of the pulpal status.

Limitations of Study

The current study has several limitations. First, the cross-sectional design constrains the authors from determining the temporal relationship between restoration and the occurrence of pulp necrosis. The current study was conducted in a single clinic with a small sample size, and therefore the results may not be generalizable. Additionally, standard neural pulp sensitivity tests cannot measure pulpal blood flow, and the history of clinical cases regarding the placement of crowns was based on the clinical history available.

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Indo-Am. J. of Life Sc & Bt.2026 *ISSN 2347-2243 www.iajlb.com*
Vol.23, Issue 3, 2026

Indo-American Journal of Life Sciences and Biotechnology

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