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Awareness of Infrared Thermography for Non-Invasive Early Detection of Gingival Inflammation Among Dental Professionals in India: A Cross-Sectional Study

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KEYWORDS

Infrared thermography; Gingival inflammation; Periodontal diagnosis; Dental professionals; Non-invasive diagnostics

ABSTRACT:

Introduction: Infrared thermography (IRT) offers a non-invasive, radiation-free methodology for detecting gingival inflammation through thermal imaging. Despite demonstrated diagnostic accuracy (sensitivity 93% for gingivitis, 90.7% for periodontitis), awareness among Indian dental professionals remains limited, potentially hindering clinical adoption.

Aim and Objective: To evaluate awareness, knowledge and perception of infrared thermography for non-invasive early detection of gingival inflammation among dental professionals in India.

Material and Methods: A cross-sectional descriptive survey was conducted among 318 dental professionals across urban and semi-urban areas in India using a validated 25-item questionnaire administered via Google Forms. The instrument comprised demographic questions (5 items), knowledge-based assessment (10 multiple-choice items), perception evaluation (10 Likert scale items), clinical practice questions (3 items) and open-ended queries (2 items). Data were analyzed using SPSS version 28.0 with descriptive statistics, chi-square tests and one-way ANOVA ($p<0.05$).

Results: Of 318 respondents, 64.15% (n=204) demonstrated moderate awareness of IRT principles. Knowledge regarding temperature-based detection of inflammation was demonstrated by 71.07% (n=226) of participants. Perception of clinical feasibility scored a mean of 3.68±1.02 on a 5-point Likert scale. Notably, 58.81% (n=187) indicated willingness to incorporate IRT into their practice if adequate training and resources were provided. Cost barriers were identified by 76.10% (n=242) as a significant constraint. Specialists demonstrated significantly higher awareness compared to general practitioners ($p=0.0012$). Open-ended responses (n=85) highlighted requirements for standardized protocols and cost-effective implementations.

Conclusion: Dental professionals demonstrate moderate awareness of infrared thermography with considerable enthusiasm for clinical adoption contingent upon training accessibility and economic feasibility. Integration of IRT into periodontal practice necessitates systematic educational initiatives, standardized diagnostic protocols, and cost-effective instrumentation strategies. This study establishes a foundational baseline for thermography-centered awareness campaigns and suggests targeted interventions to bridge the knowledge-practice gap in Indian dentistry.

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Introduction

Periodontal disease is among the most prevalent chronic inflammatory conditions globally, with periodontitis ranking as the sixth most common human disease, affecting approximately 10–15% of the population.[1] In India, prevalence ranges from 65–90%, representing a significant public health burden.[2] Traditional diagnostic methods for periodontal disease (clinical probing, radiographic assessment, gingival indices) rely on visual examination and mechanical instrumentation. While these conventional approaches remain the gold standard, they have inherent limitations including operator dependency, patient discomfort, risk of iatrogenic tissue trauma, and inability to detect subclinical inflammatory changes preceding clinical manifestation.[3] Furthermore, the elevation in temperature (calor), one of the cardinal signs of inflammation, is systematically underestimated in conventional chairside diagnosis, despite being a reliable indicator of inflammatory activity.[4]

Infrared thermography (IRT) represents an innovative diagnostic modality that measures thermal radiation emitted from biological tissues.[5] Clinical investigations have demonstrated high accuracy, IRT exhibits sensitivity of 93% and specificity of 87% for diagnosing gingivitis and comparable accuracy (sensitivity 90.7%, specificity 85.3%) for detecting periodontitis.[6] This non-invasive, radiation-free method provides real-time visualization of temperature gradients corresponding to local inflammatory processes and vascular changes in periodontal disease.[7] Advanced thermal imaging systems can detect temperature variations as minute as 0.02°C, enabling early detection of metabolic disruptions that may precede overt clinical inflammation.[8]

Despite its demonstrated diagnostic efficacy and patient-centric advantages, widespread adoption of infrared thermography within the Indian dental community remains limited. A bibliometric analysis identified only 119 published thermography studies across all dental specialties, with only 3 focusing on periodontal diagnosis, reflecting a substantial knowledge gap.[6] Factors likely influencing adoption patterns include limited professional awareness, inadequate technical knowledge, economic concerns, absence of standardized guidelines, and insufficient training opportunities. Understanding these barriers and current perceptions is essential for guiding educational interventions and integration strategies.[9]

The present investigation was conceptualized to evaluate awareness, knowledge, and professional attitudes toward infrared thermography among dental practitioners across India. Understanding existing perception and barriers is critical for developing targeted educational interventions and implementation strategies to facilitate integration of this promising technology into routine periodontal practice.

Aims and Objectives

Aim: To evaluate awareness, knowledge, and professional perception regarding infrared thermography for non-invasive early detection of gingival inflammation among dental professionals in India.

Objectives:

- To assess the baseline awareness and knowledge of infrared thermography principles and applications in periodontal diagnosis among dental professionals.
- To analyze professional perception regarding clinical feasibility, cost-benefit ratios, and barriers to implementation of IRT in Indian dental practice.
- To determine the association between professional experience, specialization, and awareness/knowledge levels.
- To identify demographic variables influencing adoption likelihood and recommend targeted intervention strategies.

Materials and Methods

Study Design: A descriptive cross-sectional survey employing convenience sampling was conducted to systematically evaluate awareness, knowledge, and professional perception of infrared thermography among dental professionals.

Study Population and Sampling:

Inclusion Criteria: Registered dental professionals (BDS or higher), with ≥1 year clinical practice, active in India and willing to consent.

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Exclusion Criteria: Dental professionals with <1 year clinical experience, not engaged in clinical practice, incomplete questionnaire responses (>15% missing) and non-registered practitioners.

Sample Size Calculation: Using $n = Z^2[P(1-P)]/d^2$ (Z=1.96 for 95% confidence, P=0.50, d=0.055), the required sample size was 318 participants.

Study Instrument: A validated 25-item questionnaire was developed through iterative expert consultation and pilot testing. Content validity (CVI>0.80) and reliability (Cronbach's α=0.79) were confirmed during pilot phases. The final questionnaire comprised five sections: 5 demographic questions, 10 multiple-choice knowledge items, 10 five-point Likert-scale perception items, 3 clinical practice questions, and 2 open-ended questions.

Data Collection Procedure: The questionnaire was administered via Google Forms with standardized instructions. Participants were recruited through email and WhatsApp, providing electronic informed consent. Data were collected over 10 weeks (September–November 2025) with automated reminders at 1, 2, and 3 weeks to improve response rates. Responses were anonymized using unique codes; no incentives were offered to avoid bias.

Data Management and Analysis: Data were analyzed using SPSS Statistics v28.0. Descriptive statistics (frequencies, percentages, means, SDs) were computed. Normality and homogeneity of variance were assessed (Shapiro–Wilk, Levene's tests). Group comparisons used independent t-tests (continuous variables) and chi-square tests (categorical variables). One-way ANOVA (with Tukey's HSD) compared awareness scores across groups; Pearson's correlation assessed relations between experience and awareness/knowledge. Thematic analysis of open-ended responses was performed by two independent researchers (Cohen's κ for inter-rater reliability). Statistical significance was set at $p<0.05$.

Results

Demographic Characteristics: Of 380 dental professionals contacted, 318 completed the questionnaire (response rate 83.68%). Participant demographics are summarized in **Table 1**. The mean age was 32.14±8.76 years (range 23–58). Males comprised 58.49% of respondents. Most had BDS degrees (52.20%), followed by MDS specialists (38.36%) and PhD holders (9.43%). Mean clinical experience was 7.82±6.43 years (range 1–32). General practitioners made up 44.03% of respondents, periodontists 28.30%, implantologists 16.35%, and other specialists 11.32%.

Table 1: Demographic characteristics of respondents (n=318).

Variable	Value
Mean age, years	32.14 ± 8.76 (range 23–58)
Gender (Male)	186 (58.49%)
Educational Qualification	BDS: 166 (52.20%), MDS: 122 (38.36%), PhD: 30 (9.43%)
Mean clinical experience, years	7.82 ± 6.43 (range 1–32)
Specialization	General Practice: 140 (44.03%), Periodontology: 90 (28.30%), Implantology: 52 (16.35%), Other: 36 (11.32%)

Awareness Assessment:

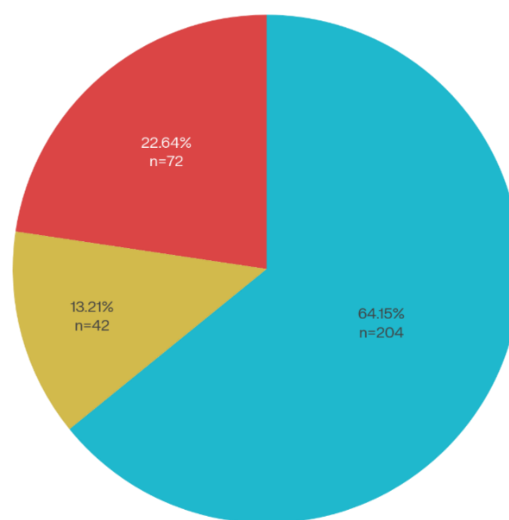

Figure 1: *Overall awareness distribution among respondents (n=318).*

Overall, 64.15% of respondents demonstrated moderate awareness of infrared thermography; 22.64% reported limited awareness and 13.21% reported no prior

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awareness (Figure 1). Specialists had significantly higher awareness than general practitioners (78.43% vs. 48.57%; χ^2=28.41, p=0.0012; OR=3.87, 95% CI: 2.41–6.22). Awareness correlated positively with clinical experience (r=0.324, p<0.001); those with >10 years' experience showed higher awareness than those with 1–5 years (73.21% vs. 52.38%; χ^2=12.87, p=0.0003).

Knowledge Assessment:

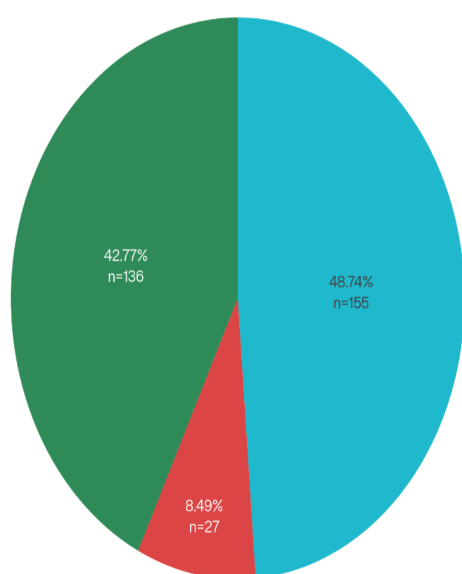

Figure 2: *Knowledge category distribution among respondents (n=318).*

Overall, 48.74% of respondents demonstrated good knowledge of infrared thermography, 42.77% showed moderate knowledge, and 8.49% had poor knowledge (Figure 2). 71.07% correctly identified temperature variations as the mode of inflammation detection; 68.24% recognized the non-invasive nature of thermography. Only 54.40% accurately identified the reported diagnostic sensitivity for gingivitis. Understanding of real-time inflammation mapping was correct in 61.32%, whereas only 47.17% recognized environmental interference as a primary limitation. Familiarity with AI integration in thermography was low (38.99%). Specialists achieved significantly higher knowledge scores than general practitioners (mean 7.24±1.87 vs. 5.18±2.14, t=9.73, p<0.0001).

Perception Analysis:

Overall professional perception of infrared thermography was moderately favorable (mean score 3.68±1.02 on a 5-point scale). Most respondents agreed that thermography offers clinical utility (67.29%) and substantial patient benefits through early disease detection (82.39%). Cost was identified as a major barrier: 76.10% considered implementation not economically feasible. A majority (78.61%) believed comprehensive training would significantly enhance adoption, and 59.43% perceived added diagnostic value from AI integration. Environmental factors were acknowledged as limitations by 58.49%; data privacy and ethical concerns were cited by only 28.93%. Approximately half (51.26%) anticipated that thermography would become a standard diagnostic modality in periodontal practice within the next five years.

Table 2: Perception of infrared thermography among respondents (n=318).

Statement	Agree, n (%)
Thermography offers clinical utility	214 (67.29%)
Provides substantial patient benefits through early detection	262 (82.39%)
Implementation is economically feasible	76 (23.90%)*
Comprehensive training would significantly increase adoption	250 (78.61%)
Integration with AI enhances diagnostic utility	189 (59.43%)
Environmental factors limit thermography accuracy	186 (58.49%)
Data privacy/ethical issues concern me	92 (28.93%)
Anticipate thermography as standard within 5 years	163 (51.26%)

**76 respondents (23.90%) agreed implementation is economically feasible (i.e., 76.10% saw it as not* feasible).

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Clinical Practice and Adoption Intention:

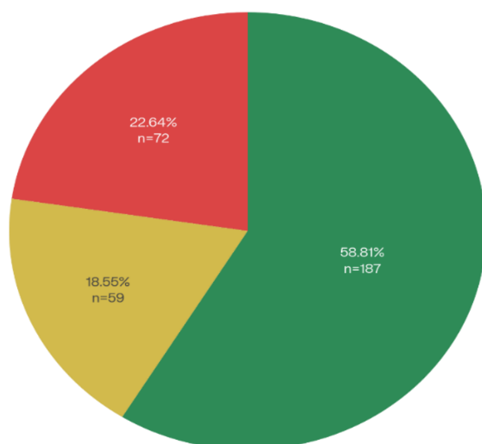

Figure 3: *Adoption intention regarding thermography (n=318).*

Overall, 58.81% of respondents indicated willingness to adopt thermography in practice if adequate training were provided, 22.64% were unwilling, and 18.55% were uncertain. Only 12.26% had prior exposure to thermography, indicating limited current implementation. Regarding non-invasive diagnostic practices, 52.51% reported always/often using such tools, while 47.49% reported rare/never used. Practitioners who frequently used non-invasive diagnostics had significantly higher awareness of thermography compared to those who rarely did (75.32% vs. 42.59%; χ^2=31.64, $p<0.0001$).

Open-Ended Response Thematic Analysis: Analysis of 218 open-ended responses (68.55% of respondents) revealed thematic patterns regarding barriers and implementation recommendations

Barriers to Adoption: Thematic analysis identified five principal barriers to thermography adoption (see Table 3). Economic constraints (72.94%) were most frequently cited, including high equipment costs and lack of insurance reimbursement. Knowledge and training deficits were reported by 56.47%, reflecting inadequate formal training and curriculum integration. Nearly half (48.24%) highlighted the absence of standardized protocols and India-specific reference values. Limited evidence accessibility (41.18%) and technological/infrastructural limitations (32.94%) were also noted.

Implementation Recommendations: Five major recommendation themes emerged (Table 3). Educational initiatives were most frequently suggested (72.18%), including curriculum integration and continuing education programs. Cost reduction strategies (63.16%) such as subsidized equipment and institutional procurement were recommended. Over half (54.89%) emphasized standardized protocols and guidelines. Institutional support measures (45.86%) and strengthening research infrastructure (39.09%) were also recommended.

Table 3: Thematic analysis of open-ended responses.

Barriers to Adoption (n=85)	Recommendation Themes (n=133)
Economic constraints: 72.94%	Educational initiatives: 72.18%
Knowledge/training deficits: 56.47%	Cost reduction strategies: 63.16%
Absence of standardized protocols: 48.24%	Standardized protocols/guidelines: 54.89%
Limited evidence accessibility: 41.18%	Institutional support measures: 45.86%
Technological/infrastructure issues: 32.94%	Research infrastructure: 39.09%

Discussion

This investigation represents the first systematic evaluation of awareness, knowledge, and professional perception regarding infrared thermography for gingival inflammation detection among Indian dental practitioners. Findings reveal a landscape of moderate awareness with substantial knowledge gaps, considerable enthusiasm for clinical adoption contingent upon enabling factors, and multiple barriers limiting current implementation.

Awareness Assessment: The moderate awareness level (64.15% with moderate awareness) indicates that information about IRT has begun reaching dental professionals, likely via literature and conferences. However, many respondents still had limited or no awareness, suggesting inadequate integration into formal education and training. Specialists showed higher awareness than general practitioners, reflecting

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greater engagement with specialty-specific education. This highlights a gap in dissemination, as general practitioners (the majority of the workforce) appear less exposed to emerging diagnostic technologies.[10] The positive correlation between experience and awareness implies that prolonged practice increases exposure to innovations. Nevertheless, even many senior practitioners remain only partially aware, indicating that thermography has not achieved widespread inclusion in continuing professional development.

Knowledge Assessment: Performance on knowledge questions varied widely (from 54.40% correct on sensitivity to 38.99% on AI integration), suggesting that basic conceptual awareness exists but detailed technical understanding is limited. Only 48.74% achieved a "good knowledge" score (≥7/10 correct), implying fewer than half of practitioners have adequate knowledge for meaningful clinical discussion or adoption. This indicates awareness has outpaced knowledge acquisition: many have heard of thermography but lack deep understanding of its technical and diagnostic specifics. Specialists' mean knowledge scores (7.24±1.87) were significantly higher than general practitioners (5.18±2.14, $p<0.0001$), reflecting differential access to specialist literature and training. The low familiarity with key limitations (only 47.17% identified environmental interference) and AI integration (38.99%) is concerning, as these aspects are critical for proper clinical application. Comparatively, knowledge levels in this cohort are higher than earlier studies from other regions, suggesting technology maturation has improved awareness; however, knowledge remains suboptimal for clinical implementation.[11]

Professional Perception and Adoption Intention: The overall favorable perception (mean score 3.68±1.02) and 58.81% willingness to adopt IRT indicate substantial receptivity to the technology. This adoption intent is higher than for comparable emerging technologies in dentistry, likely due to the appealing patient-centric features of thermography. The high agreement on patient benefits (82.39%) reveals that professionals recognize its advantages (no radiation, reduced discomfort), which may drive adoption efforts. Conversely, the overwhelming cost barrier (76.10%) poses the most significant obstacle.[12] This is particularly salient in the Indian context, where economic factors are critical in adoption decisions, especially in private practices serving middle-income populations. These findings imply that cost reduction strategies (institutional purchasing, subsidies, etc.) are essential prerequisites for widespread adoption. The marked discrepancy between enthusiasm for training (78.61% agree training would increase adoption) and the low rate of prior exposure (12.26%) indicates a substantial unmet need for education. Practitioners recognize that lack of knowledge hinders adoption, yet they have had few opportunities for training—a gap that targeted educational initiatives could address.

Barriers to Adoption: Open-ended responses identified five main barrier categories, with economic constraints, knowledge/training deficits, and lack of standardization most frequent. This aligns with diffusion of innovation theory, which emphasizes relative advantage (cost-benefit), compatibility with existing systems, complexity (knowledge requirement), and trialability.[13] The prominence of protocol standardization concerns (48.24%) reflects worries about diagnostic validity: thermography's utility depends on standardized image acquisition and interpretation criteria, which are lacking internationally and especially for the Indian context. The theme of limited evidence (41.18%) highlights that most research has not been India-specific, raising questions about applicability to local patient populations and healthcare settings. This echoes broader challenges in global health technology transfer, where innovations validated in developed countries need contextual adaptation in resource-limited settings.[14]

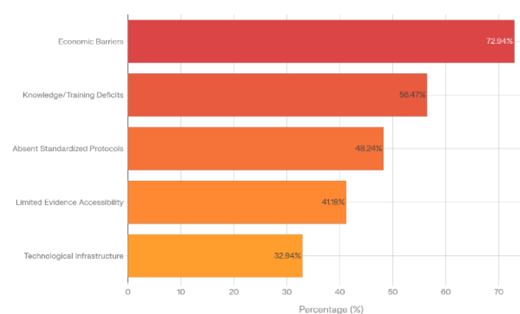

Figure 4: Primary Barriers to Thermography Adoption (Open-Ended Response Thematic Analysis)[Horizontal bar chart: Economic constraints (72.94%); Knowledge/training deficits (56.47%); Absence of

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protocols (48.24%); Limited evidence (41.18%); Technological issues (32.94%)] *Note: Economic and knowledge barriers predominate, suggesting cost reduction and educational initiatives would facilitate adoption.*

Implementation Recommendations: Respondent recommendations strongly converged with evidence-based innovation frameworks. Educational initiatives (72.18% recommendation frequency) and cost reduction (63.16%) directly address identified barriers. Professional-guided curriculum integration and guideline development (72.18% and 54.89% respectively) indicate that practitioners see institutional validation and norm-setting as critical for adoption. These targeted interventions (education, standardization, economic support) align with theories of technology diffusion and are likely to have high impact in the Indian context.

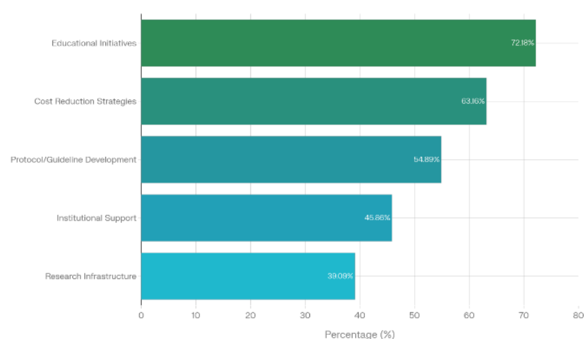

Figure 5: Implementation Recommendations Distribution (Open-Ended Response Thematic Analysis) [Horizontal bar chart: Educational initiatives (72.18%); Cost reduction strategies (63.16%); Protocol development (54.89%); Institutional support (45.86%); Research infrastructure(39.09%)] *Note: Educational initiatives and cost reduction strategies were most frequently recommended, aligning with identified barriers and suggesting targeted intervention areas.*

Conclusion

This study provides baseline data on awareness, knowledge, and professional perception of infrared thermography for gingival inflammation detection among Indian dental professionals. Given the unmet need for non-invasive periodontal diagnostics and the proven efficacy of thermography, IRT has the potential to transform periodontal practice in India. Realizing this potential, however, requires systematic, multi-stakeholder efforts addressing identified barriers within supportive policy and economic frameworks.

This study lays an essential foundation for targeted awareness campaigns, educational curriculum development, professional guideline formulation, and health technology policy decisions. Future research should implement and evaluate evidence-based interventions based on these findings to advance thermography adoption, ultimately improving diagnostic capabilities and patient outcomes in Indian periodontal care.

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Conflict of Interest: The authors declare no financial or personal conflicts of interest regarding this research or manuscript preparation.

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