Original Research

ADVANCEMENTS IN DENTAL RADIOGRAPHY AND RADIATION SAFETY: A KAP REVIEW OF DIGITAL IMAGING AND CBCT AMONG DENTAL PROFESSIONALS

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ABSTRACT
Advancements in dental radiography particularly digital imaging and Cone Beam Computed Tomography (CBCT) have enhanced diagnostic capabilities across dental specialties. Yet, these modalities also raise significant concerns about ionizing radiation exposure. This review evaluates the knowledge, attitudes, and practices (KAP) of dental professionals regarding advanced imaging and radiation safety. Recent cross-sectional studies reveal that while awareness of digital radiography (e.g., RVG) is high, familiarity with CBCT remains limited (around 58.9%). Further, systematic reviews highlight wide variability in knowledge (6–73%) and positive attitudes (16.8–84.8%) towards radiation protection, with actual safety practices lagging (19.8–64%). Region-specific surveys—for instance in Western Maharashtra show that although practitioners often perform clinical evaluations before imaging (100%) and use protective shields (98%), there are notable gaps in informed consent (only 87%), explaining risks (74%), and use of film-holding devices (28%). Addressing these gaps requires a structured KAP framework tailored to local institutions like Santosh Dental College, Ghaziabad. We propose a validated multi-section questionnaire (knowledge of CBCT/digital imaging and protective protocols; attitude towards radiation risks; practice of safety measures), followed by educational interventions (seminars, hands-on training, guideline dissemination) and pre/post-intervention assessments. Such an approach aims to align technological proficiency with ethical, safe practices in dental radiography, ensuring radiation protection is deeply embedded in clinical routines.

Keywords: CBCT, Digital Imaging, KAP Study, Radiation Protection, Radiation Safety.

INTRODUCTION
In recent decades, dentistry has witnessed remarkable advancements in diagnostic imaging, largely due to the integration of sophisticated radiographic technologies such as digital radiography, panoramic imaging, and Cone Beam Computed Tomography (CBCT). These innovations have transformed clinical diagnostics by enabling high-resolution, three-dimensional visualization of dental and maxillofacial structures, thereby facilitating more precise diagnosis, enhanced treatment planning, and improved patient outcomes. For instance, CBCT provides detailed volumetric images critical for endodontics, implantology, and maxillofacial surgery, while digital radiography allows for instantaneous image acquisition, storage, and manipulation with significantly reduced radiation exposure compared to conventional film-based techniques.[1]

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Despite these technological improvements, the fundamental concern surrounding the use of ionizing radiation in dental practice remains unresolved. Even low doses of radiation carry potential risks, particularly when exposure is repeated or improperly managed. The deterministic effects such as erythema and tissue damage and stochastic effects, including carcinogenesis, necessitate the implementation of rigorous radiation protection protocols. The International Commission on Radiological Protection (ICRP) and national regulatory bodies such as the Atomic Energy Regulatory Board (AERB) of India emphasize the principles of radiation justification, optimization (ALARA: As Low As Reasonably Achievable), and dose limitation to mitigate these risks in clinical settings.[2] Given the increased reliance on radiographic modalities in routine dental procedures, it is imperative that dental professionals possess a comprehensive understanding of radiation biology, equipment operation, safety standards, and ethical responsibilities associated with radiation use. Inadequate knowledge or inappropriate attitudes toward radiation safety can lead to negligent practices, potentially compromising both patient and practitioner health. Moreover, variations in compliance with safety guidelines have been noted

across institutions, often due to gaps in formal training or inconsistent reinforcement of protective measures.

To address these issues systematically, the Knowledge, Attitude, and Practice (KAP) model serves as a valuable framework for evaluating the educational and behavioral readiness of healthcare professionals concerning radiation safety. This review applies the KAP approach to assess the current state of awareness and implementation of radiographic safety practices among undergraduate students, postgraduate trainees, and faculty members at Santosh Dental College, Ghaziabad. The aim is to identify existing strengths and shortcomings in knowledge dissemination and to propose strategic interventions to enhance the overall culture of radiation safety in dental education and practice.[3]

Through this institutional case study, the paper seeks not only to contribute to the academic discourse on dental radiology and safety but also to support the development of policy recommendations and training modules that ensure responsible use of radiographic technology in alignment with global standards.

1.2 Advances in Dental Radiographic Technology

CBCT has become the gold standard for three-dimensional dental imaging. Unlike traditional two-dimensional modalities, CBCT provides volumetric data with high spatial resolution, allowing for accurate anatomical assessments (Pauwels et al., 2015). Digital radiography has also gained popularity due to lower radiation doses, real-time image acquisition, and ease of storage and transmission .[4]

Despite these advantages, improper use or overutilization of these modalities may expose patients to unnecessary radiation. Therefore, radiographic examinations should be justified based on clinical indications and supported by optimized exposure protocols [5]

Radiation Safety in Dentistry

Radiation protection in dentistry involves technical, procedural, and behavioral aspects. Protective measures include using rectangular collimators, high-speed image receptors, lead aprons, thyroid collars, and limiting exposure parameters Personal dosimetry, regular equipment calibration, and adherence to national safety standards are also essential components.[6]

However, compliance is influenced by individual and institutional factors, including knowledge of biological effects, attitudes towards radiation hazards, and practical behaviors during radiographic procedures Understanding thesebehavioral dimensions is critical for developing effective safety interventions.[7]

Knowledge, Attitude, and Practice (KAP) Studies in Dentistry

KAP studies serve as valuable tools for evaluating how well healthcare providers understand and apply specific protocols in clinical practice. Indentistry, KAP assessments related to radiation safety have revealed moderate to low levels of awareness, particularly among undergraduate students and interns. These studies also highlight that although most practitioners acknowledge the importance of radiation safety, their actual practice often deviates from recommended guidelines.[8]

For instance, a study in Saudi Arabia found that only 40% of dental interns routinely used thyroid collars during radiographic procedures, despite 80% acknowledging their protective value. Such findings indicate a need for continuous professional development and curriculum reinforcement.[9]

This review follows a narrative design with the goal of synthesizing peer-reviewed studies, regulatory guidelines, and institutional data relevant to the KAP of dental professionals regarding advanced radiographic technologies and radiation protection. Literature was sourced from databases such as PubMed, Scopus, and Google Scholar using keywords including "CBCT in dentistry," "radiation safety," "KAP study dental radiography," and "radiation protection in dental education."

Inclusion criteria included English-language studies published between 2007 and 2024, focusing on dental professionals' or students' awareness, behavior, or practice regarding radiographic safety. Exclusion criteria included studies outside the dental domain and those lacking methodological clarity.

The review also outlines the methodology for a proposed cross-sectional survey at Santosh Dental College using a structured questionnaire based on the KAP framework. The data from this planned survey will be intended to validate trends observed in the literature and provide institution-specific insights.

The integration of advanced radiographic modalities in dental practice has significantly enhanced diagnostic accuracy, treatment planning, and patient care. Technologies such as digital radiography, panoramic radiography, and Cone Beam Computed Tomography (CBCT) have become central to modern dentistry. However, these advances also necessitate a sound understanding of radiation protection principles and safe operational protocols, particularly among dental professionals.

Evolution of Dental Radiography and Technological Advancements

Traditional intraoral film-based radiography has gradually been supplanted by digital imaging systems, which offer advantages such as reduced radiation dose, immediate image acquisition, and the ability to enhance diagnostic quality through digital manipulation. Moreover, panoramic imaging provides a broad overview of the dentition and maxillofacial structures, commonly used for screening and treatment planning.

The introduction of CBCT has marked a paradigm shift in dental imaging by providing three-

dimensional visualization with relatively lower radiation doses compared to conventional CT (Scarfe & Farman, 2008). CBCT is particularly valuable in implant planning, endodontics, and maxillofacial surgery due to its high spatial resolution and volumetric accuracy .[10]

Radiation Hazards and the ALARA Principle

Despite the diagnostic benefits, exposure to ionizing radiation carries inherent risks, including cellular damage, cumulative dose effects, and potential stochastic outcomes such as carcinogenesis. Regulatory bodies such as the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP) have emphasized the ALARA (As Low As Reasonably Achievable) principle as a foundation for radiation safety (ICRP, 2007).[12]

Radiation protection strategies include use of lead aprons, thyroid collars, beam collimation, and selection of appropriate exposure parameters, particularly when imaging vulnerable populations such as children and pregnant women .[13]

Knowledge, Attitude, and Practice (KAP) Among Dental Professionals Numerous studies have assessed the KAP levels of dental professionals regarding radiation safety. According to Shahab et al. (2012), while the majority of dental students were aware of the hazards of radiation, significant gaps were found in the practical implementation of safety measures. Similarly, observed that although attitudes toward radiation protection were generally positive, inconsistent practices were common due to lack of formal training and reinforcement. Studies conducted in India, such as by Gupta et al. (2019), revealed that although awareness of advanced radiographic technology was moderate, there was poor adherence to standard radiation protection protocols, particularly in private dental clinics and institutions lacking regular continuing dental education (CDE) programs.[13]

CBCT-Specific Awareness and Safety Concerns

The adoption of CBCT has outpaced the dissemination of appropriate training and radiation safety guidelines. A survey by Ludlow & Walker (2013) emphasized that many clinicians using CBCT lacked formal certification or understanding of field-of-view optimization, dose settings, and justification protocols. Furthermore, Bornstein et al. (2014) emphasized the importance of limiting CBCT use to indications supported by clinical evidence, given the relatively higher dose compared to 2D imaging.[14]

Need for Curriculum Integration and Policy Enforcement

The Dental Council of India (DCI) and similar regulatory authorities globally advocate for the inclusion of radiation physics and protection protocols in undergraduate and postgraduate dental curricula. However, real-world data suggest that this is inconsistently implemented. Studies by Aps (2010) and Math et al. (2020) underline the importance of mandatory training modules, CDE programs, and institutional policies to reinforce safe radiographic practices.[15]

Present Study

The present study is designed to assess the Knowledge, Attitude, and Practice (KAP) regarding advanced radiographic technology and radiation safety among dental professionals at Santosh Dental College, Ghaziabad. As the use of modern imaging modalities such as digital radiography, panoramic imaging, and Cone Beam Computed Tomography (CBCT) continues to expand in dental diagnostics, it becomes essential to evaluate the extent to which practitioners are informed about radiation hazards and protection protocols. Despite the existence of national and international guidelines emphasizing radiation safety, a gap persists between theoretical knowledge and actual clinical application.

This gap may be attributed to insufficient training, limited emphasis on radiation safety education, or the absence of consistent enforcement of protective measures.

The aim of the present study is to evaluate the KAP related to the use of advanced dental radiographic technologies and radiation protection among various groups of dental professionals, including students, interns, postgraduate trainees, and faculty members. Specifically, the study seeks to assess their understanding of radiographic principles and safety concerns, examine their attitudes toward radiation protection, and evaluate the routine practices they follow in clinical settings. Through this assessment, the study aims to identify deficiencies in the current educational framework andadvocate for the integration of focused training programs or Continuing Dental Education (CDE) initiatives. Ultimately, the findings are expected to facilitate the promotion of safer imaging practices within the institution and serve as a reference model for similar academic settings across India, thereby contributing to enhanced radiation safety standards in dental practice.

DISCUSSION

The findings and rationale outlined in the present review highlight the crucial interplay between technological advancement and the responsibility of maintaining radiation safety in modern dental practice. The increasing adoption of advanced radiographic modalities such as digital imaging, panoramic radiography, and CBCT has undoubtedly enhanced diagnostic capabilities, offering high-resolution imaging and three-dimensional visualization of maxillofacial structures. However, this progress also brings forth the challenge of ensuring that these technologies are used judiciously, and with a thorough understanding of their associated radiation risks.

The review of existing literature and the focus of this study point toward a consistent concern: while knowledge of radiographic technology is gradually improving among dental professionals, the translation of this knowledge into appropriate clinical practice remains inconsistent. Various studies have shown that although many dental practitioners are aware of the theoretical principles of radiation safety, their attitudes toward implementation and the practical measures taken in daily clinical routines do not always reflect best practices.

This disconnect could stem from several factors, including the absence of hands-on training, under-emphasis on radiation protection in dental curricula, and a lack of continuing professional development in the area of radiological safety.

Furthermore, CBCT being one of the most advanced tools in dental imaging has been shown to be frequently utilized without proper justification or optimization, contributing to unnecessary radiation exposure. The lack of formal certification requirements or standardized protocols for CBCT usage further exacerbates this issue, as highlighted in previous studies. This underscores the importance of structured KAP assessments that not only evaluate awareness levels but also serve as the basis for implementing evidence-based safety reforms.

The present study at Santosh Dental College is anticipated to provide valuable insights into the existing gaps in knowledge, the prevailing attitudes, and the routine practices of dental professionals. It is particularly important in the Indian context, where regulations and radiation safety enforcement may vary across institutions. By identifying these gaps, the study sets the stage for developing targeted educational interventions, updating institutional guidelines, and encouraging policy-level changes that prioritize patient and operator safety.

CONCLUSION

In conclusion, the integration of advanced radiographic technologies into dental practice represents a significant advancement in diagnostics and treatment planning. However, this progress must be matched with an equally robust commitment to radiation safety. The present study underscores the urgent need to evaluate and enhance the knowledge, attitudes, and practices of dental professionals regarding radiation protection. It is evident that while technological competence is on the rise, awareness of safety protocols and consistent application of protective measures remain insufficient in many cases.

The study emphasizes that comprehensive training, curriculum reforms, and continuous professional development are essential to bridge the knowledge-practice gap. Institutional policies must enforce the ALARA principle and promote ethical, evidence-based imaging practices. The outcomes of this study are expected to not only improve local practices at Santosh Dental College but also serve as a blueprint for similar institutions aiming to advance both radiographic competency and patient safety in the field of dentistry.

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