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CBCT Perceptions of Radiology Leaders in the Midwest Dental Schools: A Qualitative Study

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ABSTRACT

CBCT PERCEPTIONS OF RADIOLOGY LEADERS IN THE MIDWEST DENTAL SCHOOLS–A QUALITATIVE STUDY

by

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Chair: Jay Brand

ABSTRACT OF GRADUATE STUDENT RESEARCH

Dissertation

Andrews University

College of Education and International Services
School of Leadership

Title: CBCT PERCEPTIONS OF RADIOLOGY LEADERS IN THE MIDWEST DENTALSCHOOLS–A QUALITATIVE STUDY

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Problem

The integration of Cone Beam Computed Tomography (CBCT) in dental education is hindered by a lack of formal training among radiology leaders, insufficient institutional support, and financial constraints. Despite the proven efficacy of CBCT in enhancing diagnostic accuracy and treatment planning, its adoption in pre-doctoral curricula remains limited. This gap in education poses significant challenges for dental graduates, who are increasingly expected to utilize advanced imaging technologies in clinical practice.

Purpose of Study

This qualitative study aimed to explore the perceptions of radiology leaders in Midwest dental schools regarding the integration of CBCT education into pre-doctoral

curricula. The objectives are to identify the barriers and facilitators to incorporating CBCT education, assess the perceived necessity of CBCT training for fourth-year dental students, and evaluate the impact of CBCT on diagnostic accuracy, clinical efficiency, and legal risk management.

Method

The study employed a qualitative research design, utilizing interpretive analysis to examine interview responses from ten radiology leaders at Midwest dental schools. Data were collected through face-to-face interviews conducted at the Annual Radiology Meeting in Hawaii. The interviews were validated using content validity and triangulation methods. Interpretive analysis was used to summarize the main features of the dataset.

Findings

The findings revealed that many radiology leaders lack formal training in CBCT technology, which became prevalent after the 1990s. Overburdened with clinical responsibilities and teaching commitments, these leaders face significant challenges in integrating CBCT education into the curriculum. Institutional support and recognition for CBCT education are also lacking, further hindering its adoption. Despite these challenges, the study highlights the necessity of CBCT education for accurate diagnosis and treatment planning. Effective teaching methods, such as hands-on training and case discussions, are identified as crucial for enhancing students' learning experiences. The integration of CBCT technology into clinical practice has been transformative, significantly improving patient care, clinical efficiency, and diagnostic precision.

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A Dissertation

Presented in Partial Fulfillment

of the Requirements for the Degree

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APPROVAL BY THE COMMITTEE:

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LIST OF ABBREVIATIONS

2-D	Two Dimensional
3-D	Three Dimensional
CBCT	Cone Beam Computed Tomography
CE	Continuing Education
CODA	Commission on Dental Accreditation
COVID-19	Coronavirus disease, 2019 variant
CT	Computed Tomography
ENT	Ear Nose Throat
IRB	Institutional Review Board
MeSH	Medical Subject Heading
MRI	Magnetic Resonance Imaging
SPSS	Statistical Package for the Social Sciences
TMJ	Temporomandibular Joint

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CHAPTER 1

INTRODUCTION

A significant number of studies have extolled the use of cone-beam computed tomography (CBCT) in its practical applications in medical, dental, and surgical fields. (Scarfe & Farman, 2008). Unfortunately, limited teaching and training on CBCT and 3-D (three-dimensional) anatomy has been conducted for pre-doctoral students in the curriculum for radiology leaders in the Midwest (Parashar et al., 2012). Given that dental faculty members and students use CBCT in their daily practice, the educational curriculum is hindered from the lack of faculty training and calibration on CBCT in the pre-doctoral curriculum. Introducing 3-D anatomy teaching became popular in the COVID-19 period (Corte-Real et al., 2021). 3-D anatomy teaching allowed students to have a deeper appreciation and understanding of the human anatomy (Shapiro et al., 2020). Integration of CBCT and 3-D anatomy became an essential tool in comprehending the anatomy for clinical application purposes (Sarment & Christensen, 2014).

Dentistry is a ubiquitous healthcare need that is continuously evolving and relying more on efficient technologies. The pre-doctoral students are highly likely to utilize CBCT technology in their private clinics upon graduation. They are morally and legally responsible for using CBCT wisely in the beneficence of their patient's well-being and best interest. Great value was provided by the radiology position paper on surgical implants. (Tyndall et al., 2012). They mentioned eleven recommendations for general practitioners and specialists and emphasized prescribing CBCT for various implant

surgery planning purposes. The radiology and endodontic groups delivered a paper on the ethical use of cone beam systems. (Use of cone-beam computed tomography in endodontics Joint Position Statement of the American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiology, 2011). This technology has proven helpful in diagnosing complex diseases such as tooth-induced painful sinusitis, cysts, tumors, and metastasis of cancerous diseases (Estrela et al., 2022). We use CBCT in radiology and otolaryngology to evaluate maxillary sinusitis and detect tumors in the head and neck region (Miran et al., 2022).

Training and Education

Current widespread use of CBCT in clinical practice, often without adequate orientation within dental school curricula, suggests a need for better alignment between academic training of dental radiology and clinical experience. It is thus highly recommended that a radiologist teach CBCT in radiology courses. Currently, there is only one lecture for CBCT in some courses. Radiology courses tend to emphasize learning the basics of 2-D imaging, diagnosis, technology, and pathology evaluation of head and neck region. There is minimal CBCT teaching in the pre-doctoral curriculum while several schools do integrate CBCT for clinical application.

At the University of Detroit Mercy, we started a new CBCT course in Fall 2020 for fourth year pre-doctoral students. The course included learning the fundamentals of CBCT technology, clinical application, independent software training, and evaluation by pre-doctoral students. This course comprised CBCT anatomy, interpretation, digital workflow integration, and hands-on training for pathology evaluation using CBCT software. Hands-on training for 3-D printing, virtual implant surgery, and guided image

surgery for pathology were included (Beacham et al., 2018). Pre-doctoral students take midterm and final exams. Students must submit an assignment on virtual implant surgery and participate in classroom virtual implant planning and surgery.

The CBCT course evaluation revealed significant improvement in student confidence in diagnosis and treatment planning in clinics. With this additional training, many students have the foundation to solve challenging cases in their private practice.

Significance of CBCT in Clinical Research

CBCT is a valuable diagnostic tool in clinical research (Bueno et al., 2021). We use it in most specialties of medicine, dentistry, and surgery. The significance of CBCT research is mentioned in dosimetry, surgery planning, and post-operative evaluation of surgery (Carter et al., 2016).

In medicine, we use it for research in maxillary sinusitis of endodontic origin and pathology evaluation in the abdominal region (Planz et al., 2019). The ENT (ear, nose, throat) group has seen benefits to their patients from this study. They used it to minimize radiation doses for patients in medicine, significantly reducing the radiation dose for patients. Ludlow et al. (2006) discovered that the radiation dose was significantly lower when they used CBCT for patients.

In dentistry and surgery, we use CBCT in almost all specialties of dentistry and surgery (Kirlys et al., 2022), transforming dental and maxillofacial surgery over the last two decades. Many dental surgeons use this technology to improve the diagnostic efficacy and accurate treatment planning for patients. Dental specialists are using CBCT in their everyday practice, improving clinical efficiency, patient care, and production of clinics, including

1. Oral and maxillofacial surgery, essential for diagnosis of head and neck diseases in such surgeries;
2. Orthodontics, widely used to straighten the teeth and treat dental-craniofacial disorders;
3. Endodontics: root canal treatment and dental emergencies;
4. Radiology: the diagnosis of head and neck diseases using 2-D radiographs and 3-D information;
5. Pathology: evaluation of diseases using microscope and histopathology with histologic slides;
6. Oral Medicine: diagnosis and treatment of head and neck diseases, corelating them with general body health;
7. Orofacial Pain: treatment of temporomandibular joint (TMJ) diseases and myofascial pain disorders;
8. Oral and maxillofacial prosthodontics: delivering temporary and permanent dentures to patients;
9. Periodontics: surgical treatment of gums and plastic surgery of the oral cavity; and
10. Implantology: providing implants to patients with surgical needs.

CBCT has increased the diagnostic efficacy of diseases in medicine and dentistry (Rosen et al., 2022). The wide range of applications of CBCT has revolutionized the precision of patient care and treatment planning (American Dental Association Council on Scientific Affairs, 2012). However, limited CBCT teaching by radiology leaders exists for pre-doctoral students (Parashar et al., 2012). There have been lawsuits against graduates for misdiagnosis and poor treatment planning for failing to implement CBCT in

patient care (Marei, 2013). Several studies have observed that CBCT technology is taught in residency programs in the US (Beals et al., 2020). However, in the Midwest there needs to be clear information on radiology leadership perception for advancing CBCT teaching in pre-doctoral dental schools. CBCT application has transformed dental practice. Many dental graduates are taking continuing education (CE) on CBCT to implement in their private practice. Radiology leadership has suggested CBCT be taught to pre-doctoral dental students in a structured curriculum.

In view of this general interest in and use of CBCT, strengthening academic precursors to clinical and research use of this technology seems necessary. To ensure this implementation proves to be effective, research discovery of the perspectives of academic radiologists tasked with training dentists and dental radiologists would be useful. This study will help clarify the radiology leadership perceptions about teaching CBCT to pre-doctoral students in the Midwest to aid in making the correct clinical diagnosis and planning treatment. Such a practice will provide accurate diagnoses to patients, increase clinical efficiency, and reduce lawsuits for clinicians.

The objective of this study was to discover Midwest radiology leadership perception on teaching CBCT to pre-doctoral fourth-year dental students to enable them to make correct clinical diagnoses and treatment plans.

Significance of the Study

CBCT is frequently used in most dental procedures for making an accurate diagnosis (Adibi et al., 2012, p. 1438). For instance, it detects dental diseases in the head and neck region (Amarin et al., 2022, p. 3). The American Academy of Oral and Maxillofacial Radiology released a position paper on prescribing CBCT for dental

implant planning (Tyndall et al., 2012). The American Academic of Endodontics and American Academy Oral Maxillofacial Radiology published a joint position paper suggesting CBCT scans for endodontics purposes (Joint Position Statement of the American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiology, 2011). The CBCT is not taught to pre-doctoral dental students in the Midwest. There is a need of insightful research on the perception of radiology leaders in teaching CBCT to dental students in the Midwest, United States, and internationally (Parashar et al., 2012, p. 1446). This study will provide a clear understanding of radiology leader perceptions about teaching CBCT to fourth-year dental students in the Midwest.

Research Questions

Primary Research Question

How do radiology leaders perceive the impact of CBCT education on the diagnostic accuracy, clinical efficiency, and legal risk management of fourth-year dental students and recent graduates in the Midwest United States?

Sub-Questions

Diagnostic Accuracy

1. How does CBCT education influence the ability of fourth-year dental students and recent graduates to make accurate diagnoses?
2. What specific skills and knowledge from CBCT education are deemed essential for improving diagnostic accuracy?

Clinical Efficiency:

1. In what ways does CBCT education contribute to increased clinical efficiency among radiology leaders and graduate students?
2. What are the most effective teaching methods for CBCT education to enhance clinical efficiency?

Legal Risk Management:

1. How does CBCT education help in reducing the likelihood of lawsuit for graduates and radiology leaders.
2. What are the perceived challenges and solutions related to the cost and accessibility of CBCT technology in dental education?

Delimitation of the Study

Radiology teachers of fourth year pre-doctoral dental students will be selected for this study. Teachers of the remaining dental students and residents will not be included. This study will improve the ability of radiology leaders to prepare the next generation of dental graduates to use holistic CBCT application in their dental practices.

Delimitations of the Study

1. The study included ten radiology leaders from the Midwest dental schools due to their busy schedules with clinical teaching and private practice. Recruiting more than ten radiology leaders was challenging given the scope of this study.

2. Eight interview questions were crafted to respect the time constraints of the ten radiology leaders, as it was anticipated that they might decline participation if more than eight questions were posed.
3. Radiology leaders from Midwest dental schools were selected to focus specifically on this region within the United States, acknowledging that the radiology curriculum might vary among different schools in the United States and Canada.
4. Licensed dentists were excluded from the study because they have access to CE on CBCT, which could influence their responses and perspectives.
5. Financial implications for insurance providers were not included in the study, as their specific policies and procedures were beyond the scope of this academic project.

Limitations of the Study

1. Many radiology leaders may hold differing views on teaching CBCT to pre-doctoral students due to personal biases regarding the use of CBCT technology.
2. It was uncertain whether radiology leaders would share truthful insights about CBCT technology, despite having CBCT machines in their radiology departments.
3. Understanding the rationale behind utilization of CBCT machines in radiology clinics by radiology leaders who had not undergone formal CBCT technology training remains enigmatic.

4. There was a possibility that radiology leaders might not be entirely honest about technology due to potential financial gains from using CBCT technology as a critical diagnostic tool in their departments.

Definition of Terms

In the realm of dental education, understanding the terminology related to advanced imaging technologies is crucial. This dissertation, "CBCT Perceptions of Radiology Leaders in Midwest Dental Schools: A Qualitative Study," delved into the perspectives of key academic figures on the use of CBCT. To facilitate comprehension, we defined essential terms such as CBCT, radiology leaders, and dental implants. These definitions aimed to provide a clear foundation for exploring how these technologies and roles impact dental education and practice. By clarifying these terms, we can better appreciate the significance of CBCT in modern dental schools.

***2-D Conventional Radiographs*:** Traditional two-dimensional X-ray images used to view the internal structures of the body (RSNA, 2024).

***3-D Imaging*:** Advanced imaging techniques that create three-dimensional representations of structures, providing more detailed information than 2-D images (RSNA, 2024).

Accuracy: The degree to which a measurement or estimate correctly reflects the true value (Hyman et al., 2023; Schaffer et al., 2017).

***CBCT Education*:** The process of teaching and learning the principles, applications, and interpretation of CBCT in clinical practice (Rabiee et al., 2018; Scarfe & Angelopoulos, 2018).

Cone Beam Computed Tomography (CBCT)*:* A medical imaging technique that provides 3-D images of dental structures, soft tissues, nerve paths, and bone in a single scan (Rabiee et al., 2018; Scarfe & Angelopoulos, 2018).

Dental Implants**:** Artificial tooth roots placed into the jaw to support replacement teeth or bridges (Esposito et al., 2006; Misch, 2015).

Diagnosis*:* The process of determining the nature and cause of a disease or condition through evaluation of patient history, examination, and review of laboratory data (Hirschfeld et al., 2000; Kessler et al., 2003).

Fourth-Year Dental Students: Individuals in their final year of dental school, preparing to enter professional practice (American Dental Association*,* 2024).

Lawsuit**:** A legal action or proceeding involving a dispute between parties that is resolved in a court of law (Hyman et al., 2023; Schaffer et al., 2017).

Medical Residents**:** Physicians in training who have completed medical school and are undergoing specialized training in a particular field of medicine (*JAMA*, 2024; *JAMA Internal Medicine*, 2024).

Pathology**:** The study of diseases, including their causes, processes, development, and consequences (*JAMA*, 2024; JAMA Network Open, 2024).

Radiology**:** The medical specialty that uses imaging techniques to diagnose and treat diseases within the body (American College of Radiology, 2024; RSNA, 2024).

Radiology Faculty**:** Academic staff members who teach and conduct research in the field of radiology (American College of Radiology, 2024).

Radiology Leader**:** An individual who guides and influences the practice, education, and research in the field of radiology (American College of Radiology, 2024).

***Treatment Planning*:** The process of designing a course of medical or dental treatment based on the diagnosis and individual patient needs (Esposito et al., 2006; Misch, 2015).

Rationale of the Study

The purpose of this study was to explore the perceptions of radiology leaders in the Midwest using Cone Beam Computed Tomography (CBCT) and its implications for clinical practice. This study is grounded in three key areas:

Making a Correct Diagnosis by Graduates

Justification

Accurate diagnosis is fundamental to effective patient care. Understanding radiology leaders' perceptions of CBCT can provide insights into its reliability and diagnostic accuracy.

Significance

By identifying the strengths and limitations of CBCT from the perspective of experienced radiologists, the study aims to enhance the diagnostic skills of new dental school graduates. This can lead to better patient outcomes and increased confidence in clinical decision-making.

Increasing Clinical Efficiency

Justification

Clinical efficiency is crucial in a fast-paced healthcare environment. CBCT technology has the potential to streamline diagnostic processes and improve workflow.

Significance

The study will assess how radiology leaders perceive the impact of CBCT on clinical efficiency among fourth-year dental students and recent graduates. Insights gained can inform training programs and operational strategies, leading to more efficient use of resources and reduced patient wait times.

Reducing Lawsuits on Graduates After Graduation

Justification

Legal issues arising from diagnostic errors can have significant financial and reputational consequences for healthcare professionals. Understanding the role of CBCT in reducing diagnostic errors is essential.

Significance

By evaluating radiology leaders' views on the effectiveness of CBCT in minimizing diagnostic errors, the study aims to identify best practices that can be incorporated into graduate training. This can help reduce the likelihood of lawsuits and enhance the overall quality of care provided by new graduates.

Conclusion

In summary, the introductory chapter underscores the critical role CBCT plays across various medical fields, emphasizing its significance in the dental domain. Despite its proven efficacy in diagnosing and planning treatments, there is a notable shortfall in CBCT education for pre-doctoral dental students in the Midwest, caused primarily by a lack of faculty training and curriculum integration. As the COVID-19 pandemic catalyzed the importance of 3-D anatomy education, it became evident that educational gaps in CBCT and 3-D anatomy integration could enhance student understanding of

anatomy, improve clinical applications, and elevate patient care outcomes. Consequently, this chapter advocates for a structured CBCT curriculum facilitated by trained radiologists, which could mitigate existing gaps in education and better prepare dental students, thereby enhancing their diagnostic and treatment planning skills. The primary focus is the perception of radiology leaders on the necessity of CBCT education for fourth-year pre-doctoral students, underscoring the importance of equipping future dental practitioners with essential diagnostic tools. The next chapter reviews the literature on radiology leader perceptions of CBCT education and its role in making correct diagnoses, increasing clinical efficiency, and reducing lawsuits among fourth-year dental students and recent graduates.

CHAPTER 2

REVIEW OF THE LITERATURE

The transition from pedagogy to andragogy, as articulated by Malcolm Knowles in 1977, represented a fundamental shift in educational theory and practice. This transition was particularly relevant to the context of teaching CBCT in dental education, as is discussed in this literature review. Knowles' (1977a, 1977b) five-step model emphasized the importance of recognizing adult learners as self-directed individuals who bring valuable experiences to the learning process, are ready to learn when they perceive a need, and are motivated by internal factors. This approach aligned seamlessly with the needs of pre-doctoral dental students, who require practical, problem-centered learning experiences to effectively integrate CBCT technology into their clinical practice. Concurrently, the integration of Carl Rogers' Learning Theory (1969), which emphasized creating a conducive learning environment and facilitating learner self-discovery, was also particularly relevant to CBCT education. Rogers' five-step model underscored the importance of diagnosing learners' needs, establishing a positive learning climate, clarifying learning purposes, organizing resources, and continuously evaluating and adjusting the learning process. This holistic approach ensured that the unique needs of dental students were met, fostering an environment wherein they could confidently and competently apply CBCT technology in real-world scenarios. Together, these theories provided a robust framework for enhancing CBCT education, ensuring that it was both learner-centered and practically oriented.

Transition from Pedagogy to Andragogy

Applying the constructs of andragogy (Knowles, 1977a, 1977b) and Rogers (1969) to teaching CBCT in dental education requires the following perspectives.

Learner Self-Concept

In traditional pedagogical models, learners were dependent on the teacher for guidance and knowledge (Knowles, 1977a, 1977b). This dependency was evident in CBCT education for pre-doctoral dental students, where the curriculum was often dictated by faculty without considering student autonomy. However, Knowles' andragogical model posited that adults were self-directed learners who took responsibility for their own learning. This shift was crucial for CBCT education, as it suggested that pre-doctoral students should be encouraged to take an active role in their learning process, utilizing CBCT technology independently to enhance their diagnostic skills.

Experience

Pedagogy often relied on teacher experience as the primary source of knowledge. In the context of CBCT education, this was reflected in the limited teaching and training provided by non-radiology faculty. Andragogy, on the other hand, valued the learner's own experiences as a rich resource for learning. This principle supported the integration of CBCT into the curriculum in a way that allowed students to apply their clinical experiences and knowledge, thereby enriching their learning process and improving their diagnostic capabilities.

Readiness to Learn

Pedagogical learning was typically structured around a standardized curriculum, which might not be aligned with the immediate needs of students. The literature review

highlights the need for better alignment between academic training and clinical practice in CBCT education. Andragogy theory emphasized that adults were ready to learn when they experienced a need to know or to do something to perform more effectively. This readiness was particularly relevant for dental students who would soon be practicing independently. Therefore, CBCT education needs to be designed to address the practical needs and challenges students would face in their professional careers.

Orientation to Learning

Pedagogical learning was subject-centered, focusing on the acquisition of knowledge. This approach was evident in the CBCT curriculum, which often emphasized theoretical knowledge over practical application. Andragogical learning, however, is problem-centered, focusing on the application of knowledge to real-life situations. This orientation was crucial for CBCT education, as it suggested that the curriculum should have been designed to help students apply CBCT technology to diagnose and treat real clinical cases, thereby enhancing their clinical efficiency and reducing the likelihood of diagnostic errors.

Motivation

While pedagogy practice often relied on external motivators such as grades and rewards, andragogy theory recognized that adults were motivated primarily by internal factors such as self-esteem, curiosity, and the desire for personal growth. The literature review underscores the importance of intrinsic motivation in CBCT education. By fostering a learning environment that encouraged self-directed learning and practical application, educators could have enhanced student motivation to master CBCT technology, ultimately leading to better patient outcomes and reduced legal risks.

In summary, the transition from pedagogy to andragogy provided a valuable framework for improving CBCT education in dental schools. By recognizing the unique characteristics and needs of adult learners, educators could have designed a more effective CBCT curriculum that emphasized self-direction, experiential learning, readiness to learn, practical application, and intrinsic motivation. This approach aligned with the findings of the literature review, which highlighted the need for a more structured and intensive CBCT training program led by qualified radiology leaders.

Integration of Carl Rogers' Learning Theory

The integration of Carl Rogers' Learning Theory (1969), which emphasized creating a conducive learning environment and facilitating learner self-discovery, was particularly relevant to the context of teaching CBCT in dental education. As outlined below, this theory was applied using a five-step model underscoring the importance of understanding and addressing the unique needs of learners.

Diagnosis of Needs

The first step involved identifying the learning needs of pre-doctoral dental students by understanding their current knowledge, skills, and experiences with CBCT, plus discovering their goals and motivations for learning the technology. The literature review highlighted that many students lacked adequate training in CBCT, which was essential for accurate diagnosis and treatment planning in their future practices. Recognizing this gap was crucial for tailoring the educational approach to meet their specific needs.

Establishment of a Positive Learning Climate

Rogers (1969) emphasized the importance of creating a supportive and non-threatening learning environment. In the context of CBCT education, this involved building trust, showing empathy, and providing unconditional positive regard to the students. The literature review underscored the need for a learning environment where students felt comfortable exploring and mastering CBCT technology without fear of judgment or failure. This supportive climate was essential for fostering self-directed learning and encouraging students to engage deeply with the material.

Clarification of the Purposes of Learning

In this step, the goals and objectives of learning CBCT were clarified for the students. This helped to align the learning activities with their personal and professional aspirations, making the learning process more relevant and meaningful. The literature review indicated that students needed to understand the practical applications of CBCT in clinical settings, including its role in improving diagnostic accuracy and clinical efficiency. Clarifying these purposes helped to motivate students and provided a clear framework for their learning journey.

Organization and Making Available Learning Resources

The facilitator organized and provided access to various learning resources to support the students' goals. These resources included books, articles, videos, and experiential activities related to CBCT technology. The literature review highlighted the importance of hands-on training and access to CBCT software and equipment. By making these resources available, educators ensured that students had the tools they needed to develop their skills and apply their knowledge in real-world scenarios.

Evaluation and Adjustment

The final step involved evaluating the learning process and outcomes. This included assessing whether the students' needs and goals had been met and making any necessary adjustments to the learning plan to ensure continuous improvement. The literature review emphasized the importance of ongoing assessment and feedback in CBCT education. By regularly evaluating student progress and adjusting the curriculum as needed, educators could ensure that the training remained effective and relevant.

In summary, the integration of Carl Rogers' Learning Theory (1969) into CBCT education provided a valuable framework for addressing the unique needs of pre-doctoral dental students. By focusing on diagnosing learning needs, establishing a positive learning climate, clarifying learning purposes, organizing resources, and evaluating outcomes, educators could create a supportive and effective learning environment. This approach aligned with the findings of the literature review, which highlighted the need for a more structured and intensive CBCT training program led by qualified radiology leaders.

Urgency for Training

A number of CBCT studies reported on cone-beam computed tomography for its sensible use in medical, dental, and surgical arenas (Scarfe & Farman, 2008). Unfortunately, teaching and training on CBCT for pre-doctoral dental students is limited in the curriculum and is seldom provided by radiology leaders (Parashar et al., 2012). Given the fact that dental faculty members and students use CBCT in their daily practice, the educational curriculum is still hindered due to the lack of faculty training and calibration on CBCT in the pre-doctoral curriculum. CBCT has increased the diagnostic

efficacy of diseases in medicine and dentistry (Rosen et al., 2022). The wide range of applications of CBCT has revolutionized the precision of patient care and treatment planning (American Dental Association Council on Scientific Affairs, 2012).

There have been lawsuits against dental school graduates for misdiagnosis and poor treatment planning because they did not implement CBCT in patient care (Marei, 2013). Several studies observed that CBCT technology is taught in dental residency programs in the United States (Beals et al., 2020). However, clear information is needed about radiology leader perceptions about advancing CBCT teaching to pre-doctoral dental schools in the Midwest. CBCT application has transformed dental practice. Many dental graduates are taking CE on CBCT to implement in their private practice (DiVito, 2014). Radiology leaders have suggested introducing CBCT training for pre-doctoral dental students into a structured curriculum.

Search Strategy

The principal investigator explored the online database using Science Direct, PubMed, Cochrane, and Google Scholar network. Data were collected from thesis and electronic dissertation databases irrespective of the language and timelines of the research. The reviewer exercised MeSH terminologies, such as “cone-beam computed tomography,” “3-D anatomy,” and “pre-doctoral education.” The search process was composed of keywords and developed search strategies and word combinations. Table 1 displays the keywords. The search was conducted from August 30-March 12, 2023.

Table 1.

Keywords for Literature Search Process

Data Base Search No	Keywords
1	cone-beam-computed-tomography technology OR CBCT machine
2	3-D anatomy [MeSH] OR head and neck anatomy
3	pre-doctoral education [MeSH] OR undergraduate doctoral program OR doctoral program OR MD OR DDS
4	Students' perception [MeSH] OR perception of students OR students' evaluation
5	1 AND 2 AND 3 AND 4

The principal investigator completed a selection of articles in three phases. In phase one, the reviewer carefully reviewed the titles and included human studies on CBCT and 3-D anatomy in pre-doctoral education. Studies in English were included in this literature review; we excluded non-English language research and papers. The reviewer cautiously analyzed abstracts and included studies showing student perceptions of the clinical significance of CBCT in the curriculum during phase 2.

Exclusion criteria included: (a) CBCT teaching in veterinary programs, (b) animal studies on CBCT, (c) CBCT experimental studies on humans, (d) undergraduate research on CBCT, and (e) research and clinical application of MRI for 3-D anatomy.

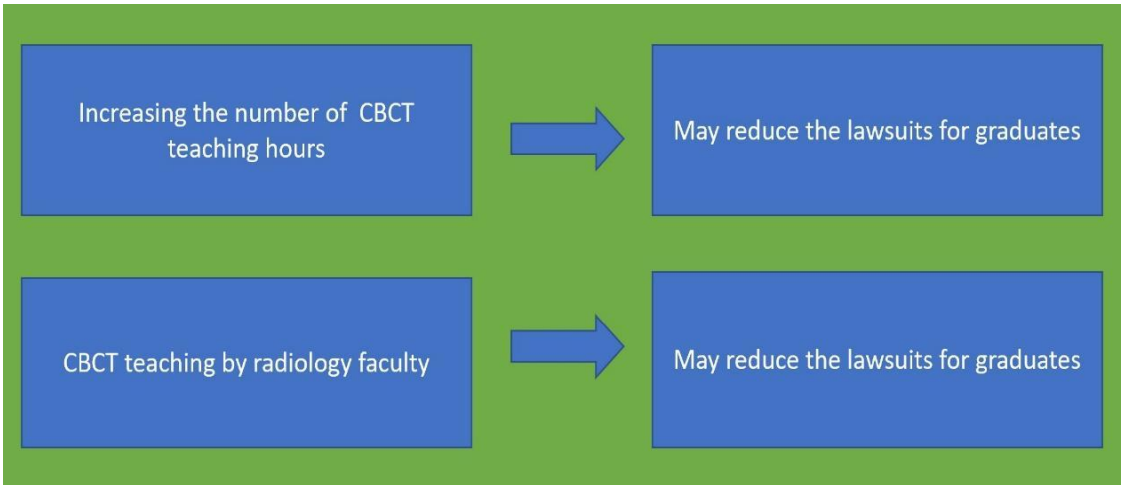
In phase 3, the reviewer evaluated all the articles thoroughly. The articles on CBCT, 3-D anatomy, digital volumetric tomography, pre-doctoral medical and dental

education, and student perception on CBCT were included in this literature review. The disagreements and questions were discussed with classmates.

Radiology leaders believed that limited CBCT teaching was adequate for pre-doctoral dental students for practicing in their private practice upon graduation. Usually, non-radiology faculty teach CBCT to pre-doctoral dental students. Observations show that these graduates need more instructional time to be ready to use CBCT in their private practices. Many graduates take CE courses and still end up with a lawsuit. Radiology leadership need to evaluate CBCT teaching in Midwest pre-doctoral dental education. Increasing the number of hours of CBCT teaching may reduce lawsuit cases of graduates in private practice. CBCT teaching by radiology faculty may improve the quality of diagnosis and treatment for dental graduates. Figure 1 displays the conceptual framework for the study.

Figure 1.

Conceptual Framework for Reducing Lawsuits for new Dental Graduates in the Midwest



This study will help understand the perceptions of radiology leaders on teaching CBCT to fourth-year pre-doctoral dental students in the Midwest to help them make correct clinical diagnoses and plan treatment. CBCT can be used to provide accurate diagnoses to patients, increase clinical efficiency, and reduce lawsuits for clinicians.

The field of dentistry is a ubiquitous overall healthcare need that is continuously evolving and relying more on the latest technology and educational research. Pre-doctoral dental students are very likely to utilize CBCT technology in their private clinics upon graduation (see Figure 1). They are morally and legally responsible for using CBCT wisely to benefit patient well-being and best interests. The radiology position paper on surgical implants was of great value. (Tyndall et al., 2012). They mentioned eleven recommendations for general practitioners and specialists and emphasized the value of prescribing CBCT for implant surgery planning purposes. The radiology and endodontic groups delivered a paper on the ethical use of CBCT (American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiology, 2011). This technology has proven helpful in diagnosing complex diseases such as tooth-induced painful sinusitis, cysts, tumors, and metastasis of cancerous diseases (Estrela et al., 2022). CBCT is used in radiology and otolaryngology to evaluate maxillary sinusitis and tumor detection in the head and neck region (Miran et al., 2022).

Training and Education

An important recommendation is that a radiology leader teach CBCT in the radiology course. Most such courses only offer one lecture for CBCT, and spend more time on learning the basics of 2-D imaging, diagnosis, technology, and pathology

evaluation of head and neck region. In the Midwest there is minimal CBCT teaching in the pre-doctoral curriculum while several schools integrate CBCT for clinical application.

At the University of Detroit Mercy, we started the new CBCT course in Fall 2020 for fourth year pre-doctoral dental students. The course includes learning the fundamentals of CBCT technology, clinical application, independent software training, and evaluation by pre-doctoral students. This course comprises CBCT anatomy, interpretation, digital workflow integration, and hands-on training for pathology evaluation using CBCT software. Hands-on training for 3-D printing, virtual implant surgery, and guided image surgery for pathology are included (Beacham et al., 2018). Pre-doctoral students take midterm and final exams. Students must submit an assignment on virtual implant surgery and attend classroom participation in virtual implant planning and surgery. The CBCT course evaluation revealed significant improvement in student confidence in diagnosis and treatment planning in clinics. Many students have now the foundation to solve challenging cases in their private practice.

Significance of CBCT in Clinical Research

CBCT is a valuable diagnostic tool in clinical research (Bueno et al., 2021), used in most specialties of medicine, dentistry, and surgery. The significance of CBCT research is mentioned in dosimetry, surgery planning, and post-operative evaluation of surgery (Carter et al., 2016).

In medicine, CBCT is used for research in maxillary sinusitis of endodontic origin and pathology evaluation in the abdominal region (Planz et al., 2019). An ENT group benefited from using this research for their patients, finding they could used it to

significantly minimize radiation doses for patients in medical practice. Ludlow et al. (2006) revealed that the radiation dose is significantly lower when CBCT is used.

In dentistry and surgery, we use it in almost all specialties of dentistry and surgery (Kirlys et al., 2022). The dental and maxillofacial surgery scope has been transformed over the last two decades. Many dental surgeons use this technology to improve their diagnostic efficacy and accurate treatment planning for patients. Dental specialists are using CBCT in their everyday practice, improving clinical efficiency, patient care, and production in clinics such as

1. Oral and maxillofacial surgery: essential for diagnosis of head and neck diseases;
2. Orthodontics where is it widely used to straighten the teeth and treat the dental-craniofacial disorders;
3. Endodontics including root canal treatment and most dental emergencies;
4. Radiology for the diagnosis of head and neck diseases using 2-D radiographs and 3-D information (CT, CBCT, and MRI);
5. Pathology, comprising evaluation of diseases using microscopes and in histopathology using histologic slides;
6. Oral medicine for the diagnosis and treatment of head and neck diseases, corelating with general body health;
7. Orofacial pain may use it for treatment of TMJ diseases and myofascial pain disorders;
8. Oral and maxillofacial prosthodontics to deliver temporary and permanent dentures to patients;

9. Periodontics, comprising surgical treatment of gums and plastic surgery in the oral cavity.
10. Implantology or providing implants to patients with surgical needs.

Data on the number of hours of CBCT teaching in Midwest dental schools is insufficient. Radiology leaders have yet to pay attention to who teaches the CBCT for fourth-year dental students in the Midwest. The number of lawsuits in the Midwest has increased for dental and maxillofacial surgery reasons.

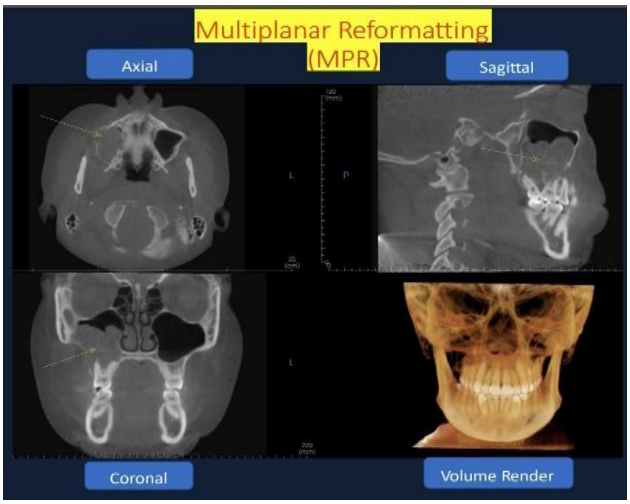
The more reputed residency programs prefer students with research backgrounds in CBCT and 3-D imaging. Students with sound CBCT background have the skills to make accurate diagnosis and treatment planning for patients. Residency programs prefer the University of Detroit Mercy graduates because our students have taken a structured CBCT training in their fourth year. We teach CBCT reconstruction and multiplanar reformatting (MPR) to medical and dental students. Figure 2 displays multiplanar reformatting. The key features are axial, coronal, sagittal, and rendered planes. For pathology evaluation visualizing the 3-D parts of head and neck region is useful.

Dosimetry Research

CBCT has given birth to good quality dosimetry research (Ludlow & Ivanovic, 2008). Ludlow et al. (2006) have contributed significantly in head and neck imaging to reduce the radiation dose for children and adults (Ludlow, 2018). High radiation dose can be a major issue in hospitals and diagnostic centers (Akdulum et al., 2021). Using CBCT scans can be used as alternatives to reduce radiation dose for CT scans. CBCT has proved valuable in otolaryngology and neuroradiology specialties.

Figure 2.

Multiplanar Reformatting (MPR) Image



Various clinical significances of CBCT exist in pre-doctoral education, clinical research, and dosimetry research. The target of this literature review was to gauge student performance on integrating cone beam computed tomography and 3-D anatomy in pre-doctoral dental education.

Materials and Methods

This literature review was accented with systematic review reporting guidelines for medical research (Page et al., 2021). Those systematic review guidelines consist of twenty-seven items for making an evidence-based decision using comprehensive and precise reporting. Such guidelines are valuable for healthcare providers, epidemiologists, policy makers, and decision makers in government agencies. These guidelines demonstrate relevance and show advances in systematic review methodology,

terminology, and recent updates. In medical research, systematic review and meta-analysis plays a vital role in decision making for physicians, specialists, surgeons, and researchers.

Data Extraction

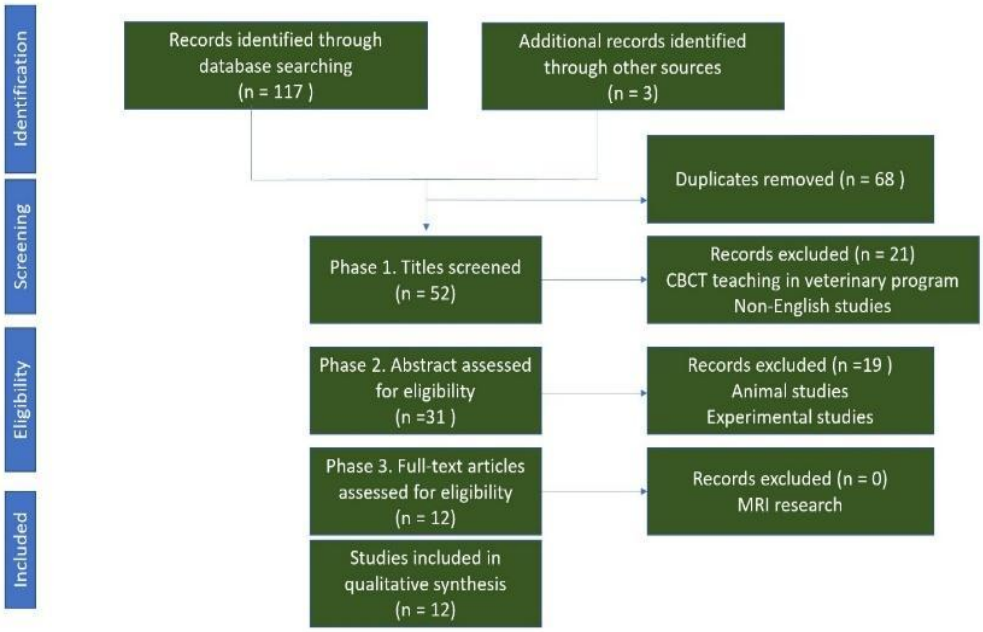
The reviewer extracted data independently and eliminated repeated articles. The reviewer followed the inclusion and exclusion criteria to eliminate repetition or to find minor details from articles. The level of significance was divulged based on what the authors disclosed. Discord was resolved with dialogue, discussion, and debate to reach consensus.

Results

Initially, the online searches of electronic database resulted in 117 articles. There were three theses and dissertations. According to Figure 3, 120 sources were found. Duplicate and repetitive articles were removed resulting in 52 total articles, followed by three phases of article search processes. The reviewer winnowed all the articles based on the title in phase 1, resulting in 52 articles. After reading abstracts, 31 articles were selected in phase 2. In phase 3, a thorough evaluation of articles resulted in 12 articles for the literature review and mixed method analysis.

Figure 3

Literature Selection Process Flow Chart in Colors



Summary: Articles 1-12

In article 1, pre-doctoral students correctly diagnosed TMJ disorders in the second computation at about eighty percent (Iskanderani et al., 2020). Their diagnoses were similar to the first computation. Most pre-doctoral students were content with the virtual program for TMJ consideration and found it beneficial for TMJ examination.

In article 2, the authors gave a clear background of CBCT principles, physics, and clinical application in dentistry and medicine (Scarfe & Farman, 2008). They commented that CBCT is a valuable diagnostic tool for treatment planning purposes.

In article 3, the third to fifth-year post-doctoral residents had a higher percentage of accurate answers regarding multi-detector CT software in comparison to CBCT software (Bailer & Martin, 2019).

In article 4, an effective outcome was observed between the two groups (groups 1 and 2) in that the CBCT teaching was significantly better. In group 2, higher scores on the Likert-type scale followed the use of webinar-style lectures with CBCT pictures.

In article 5, the sense of touch and drawing substantiated anatomy learning for pre-doctoral students. Two instructors modified the CBCT didactic components of anatomy teaching in the curriculum to improve interpretation of normal anatomy. (Shapiro et al., 2020). The touch and drawing processes were implemented to standardize and calibrate CBCT anatomy teaching for pre-doctoral students.

In article 6, the maximum learning outcome was discovered using a regular lecture and CBCT pictures. The four teaching methods implemented in the study did not show much difference in student learning outcomes (Savoldi et al., 2021). The highest subjective satisfaction was delivered by CBCT picture continued with skull lecture. Students preferred to learn CBCT anatomy by incorporating human skulls into the class. Student learning was not affected by the timing or the introduction of anatomy to these pre-doctoral students. Student tactile nature resulted in a preference for human skulls to touch and learn, enhancing anatomy learning in pre-doctoral education.

In article 7, student group learning was better than the other two groups, using yes/no questions (Khot et al., 2013). The computer-based anatomy learning using virtual reality and static images on the computer had a similar learning impact on students when learning anatomy. The students performed equally well on analysis questions in all three groups.

In article 8, the third-year medical student outcomes were better in every anatomical structure and general anatomy interpretation (Werth et al., 2018). The students demonstrated improvement in anatomy of head and chest injuries. The students performed poorly in abdominal tomography interpretation, which are essential skills (Smith et al., 2011). Many schools in the United States, England, and Australia gave advanced CBCT training to residents in structured programs.

In article 9, the response rate was moderate from most programs (n = 36) (Smith et al., 2011). Most programs had access to CBCT scanners, and many programs used CBCT on a daily basis. Generally, we use CBCT for all implant and surgery patients; however, this study had not used CBCT technology for every patient. They have used this mostly for the diagnostic purpose of pathology evaluation and specific diseases.

In article 10, many schools didn't teach students about CBCT interpretation and advanced treatment planning for pre-doctoral students. This raises significant concerns about pre-doctoral student competency in treating patients using 3-D technology in private practices.

In article 11, nearly seventy percent of respondents were incompetent when using 3-D CBCT images for interpretation and patient care purposes. On the other hand, most participants had seen and practiced interpreting CBCT virtual treatment planning. (Cheah et al., 2021). Nearly ninety-seven percent of pre-doctoral dental students expressed interest in having structured CBCT training.

In article 12, the response rate was reasonable, and over 37 programs responded to the survey. All these programs have access to CBCT units and all residents have free access to 3-D software on their operatories (Beals et al., 2020). The residents have also received training to capture CBCT scans and interpret valuable 3-D data for patient care.

Implant planning training was given to over ninety percent of the programs, and a few programs reported the fabrication of surgical guides with the help of 3-D data. All the programs use CBCT data to prepare for implant surgeries and its complications.

Discussion

Although the authors mentioned that web-based learning would be beneficial for students learning CBCT TMJ analysis, the study had a small sample size of 36 pre-doctoral students (Iskanderani et al., 2020). There was a lack of a gold standard or control group for this study. The strength of this study was that authors had followed the TMJ diagnostic criteria (Ahmad et al., 2009).

The researcher reviewed the radiation dosage for CBCT scans and fundamental principles of CBCT reconstruction clearly (Scarfe & Farman, 2008). The researcher also explained various CBCT machines produced by different manufacturers. This information is valuable for pre-doctoral students upon graduation when they purchase CBCT machines for their practices.

Bailer and Martin (2019) should have mentioned the role of radiologists in diagnosing diseases and packaging virtual treatment planning in the discussion section. This study had a low sample size (n = 48); there was no level of questioning the results in this research. The authors could have used the levels of questioning (Costa & Kallic, 2008) to categorize the questions into three levels (level 1 = assemble information, level 2 = examine information, level 3 = solicit information). Surgeons and general physicians often get confused that good software would do the job. A good radiologist is needed to interpret the disease and anatomy.

The research by Corte-Real et al. (2021) was well-designed and showed a practical application of teaching CBCT anatomy to pre-doctoral students in the COVID-19 era. The authors implemented a Likert-type scale (6-point scale) to appraise pre-doctoral students' contentment with learning anatomy with CBCT. These days, many students prefer online anatomy learning. This school moved all classes to online when the COVID-19 pandemic hit American higher education and global learning.

Shapiro et al. (2020) explained the value of the Hybrid Video on Demand process in anatomy teaching, giving an excellent picture of student perceptions of different learning methods using open-ended questions. This study could have been improved by including a quantitative research method. They could have applied Costa's level of questioning method (Costa et al., 2021) to categorize questions into three levels.

In Savoldi et al. (2021), they mentioned that students preferred lecture followed by CBCT demonstration while learning CBCT anatomy. They did not discuss online anatomy teaching even though many students now prefer online anatomy learning compared to in-person classes. The study was well-designed and covered all CBCT anatomy for teaching. The authors implemented a Likert-type scale (6-point scale) to appraise pre-doctoral student contentment with learning CBCT anatomy. The timing of CBCT training didn't appear to affect the CBCT curriculum for pre-doctoral student personal gratification and impartial learning results. CBCT learning requires a good understanding of 3-D anatomy, interpretation, and exposure to surgical and pathology cases. In our experience, we have learned that even residents and faculty members struggle to learn CBCT anatomy and interpret CBCT images.

Khot et al. (2013) revealed that physical models could be better for anatomy teaching compared to computer-based learning. The irony is many students prefer

computer-based learning over in-person and physical models. This study lacked 3-D pictures and diagrammatic representation of pelvic anatomy. There would be value in analyzing preferred method of learning anatomy by using computer or physical models.

In Werth et al. (2018), medical students were deprived of diagnosing critical diseases on 3-D scans, such as accidents and traumatic injuries to sensitive parts of the body. These students will need to go to residency programs to sharpen their diagnostic skills in reading CT scans. The authors did not mention how they deployed the questionnaire to students. They also did not follow the guidelines for the level of questioning. The research was short and to the point.

Smith et al. (2011) discussed why some programs were not using CBCT for orthodontic residency programs. They also mentioned that Eastern and Western orthodontic regions have CBCT access and training. They mentioned that 83% of orthodontics programs use CBCT imaging for treatment planning purposes. This study gave a pleasant picture of the distribution of orthodontic programs in North America. However, they did not mention the level of CBCT anatomy training used for the orthodontic residents.

Parashar and colleagues (2012) discussed how dental and medical graduates use CBCT in private practice for patients. They emphasized the ethical and moral use of CBCT technology by recent graduates. However, this study lacked a deeper understanding of CBCT training for pre-doctoral students. As one of the first studies on CBCT teaching for pre-doctoral students, the research stood out for its simplicity and an early stage of research in this field. They gathered CBCT educational information from the United States, Australia, and United Kingdom. This study opened doors to new avenues of CBCT research in medical and dental education.

Zhang et al. (2020) assumed CBCT training was equivalent for different levels of students (see also Cheah et al., 2021). Again, these authors did not follow the questioning criteria. They found that most students were aware of the significance of having a CBCT machine in private practice. The pre-doctoral students expressed a positive mindset toward learning CBCT interpretation and using the interpreting skills in their private practice. The authors did not dissect the CBCT curriculum. I question the finding that most students responded that they felt adequately skilled in interpreting CBCT images. CBCT interpretation takes years to become proficient in radiology residency program. The results did not match the pre-doctoral level use of CBCT teaching anatomy and interpretation.

Another study revealed that residents have access to CBCT, but they did not use it frequently (Beals et al., 2020). A need for CBCT training for implant planning was observed in the implant surgery program (Whitesides et al., 2015). Endodontics residents are less satisfied in comparison to program directors about CBCT teaching in residency programs (Rabiee et al., 2018). All orthodontic residency programs had free access to Invivo CBCT software to diagnose growth and development issues (Whitesides et al., 2015). This study did not cover CBCT training in Canada and other countries. They made a good point by mentioning the influence of CBCT education in implant surgery (Whitesides et al., 2015).

Seven elements emerged after evaluating the articles on CBCT and 3-D anatomy for pre-doctoral students:

1. Inconsistent didactic and clinical teachings on CBCT and 3-D anatomy were present for pre-doctoral students in medical and dental curricula (Parashar et al., 2012).

2. Faculty skill levels was one of the major challenges in teaching CBCT and 3-D anatomy to pre-doctoral students (Rabiee et al. 2018). Many faculty members lacked didactic and clinical training on CBCT.
3. CBCT and 3-D anatomy teaching was unorganized and unstructured in the pre-doctoral curriculum (Tyndall et al., 2012). The CBCT teaching was scattered across many courses.
4. A lack of interdisciplinary collaboration existed among departments on teaching CBCT and 3-D anatomy to pre-doctoral students (Smith et al., 2011).
5. I was surprised to learn that some schools didn't teach CBCT and 3-D anatomy to pre-doctoral students.
6. Although many residency programs had access to the CBCT technology and 3-D anatomy learning, the program directors were unequipped to use the technology (Beacham et al., 2018).
7. Many school leaders were not paying close attention to the advancing technology available to teach CBCT and 3-D anatomy to pre-doctoral students (Bueno et al., 2021). Leadership should invest in a good radiologist who can teach CBCT and 3-D anatomy to predoctoral students in a structured CBCT curriculum.

Throughout the literature review, there were limited data on the number of CBCT teaching hours in Midwest dental schools, and there were possibilities of lawsuits for the graduates. Many schools need a radiologist to teach CBCT to dental students.

Conclusion

There is a gap in CBCT teaching in medical and dental curricula by radiology leaders in the Midwest pre-doctoral dental schools. I was surprised to see that CBCT teaching in residency programs was inadequate. Program directors and faculty members lack skills in using CBCT technology. These findings raised reasonable questions about CBCT training for medical, dental, and residency programs.

Most CBCT courses are taught by non-radiologists, e.g., surgeons, physicians, dentists, and radiology technicians. I recommend that programs use a radiologist to teach CBCT. The medical and dental accreditation agencies recommend graduates should be able to use medical technologies such as CBCT, CT, and MRI for patient care purposes.

Structuring the CBCT curriculum in North American medical and dental education is a challenging task. Identifying well-trained faculty to teach these students is an additional challenge. We recommend further research to dissect and understand the CBCT curriculum in Midwest medical and dental institutions and diagnose the level of CBCT teaching occurring in medical and dental education. CBCT was taught in pre-doctoral and residency programs. However, CBCT didactic and clinical training for pre-doctoral students was unstructured and unorganized. All radiology leaders should work together to create a structured CBCT course for pre-doctoral dental students based on the ACGMEC guidelines for medical education.

The literature review recommends increasing the CBCT teaching hours for dental students to prevent lawsuits. A qualified radiologist should be hired to teach CBCT to dental students to enable them to make the correct clinical diagnosis and plan treatment for patients.

In summary, the literature review delved deeper into the extensive academic and empirical studies supporting the practical and clinical benefits of CBCT in medical and dental fields. Previous research on CBCT technology and training, particularly by Parashar et al. (2012), has highlighted a significant gap in the literature: the absence of CBCT research specifically targeting fourth-year dental students. While existing studies have focused predominantly on training surgery and radiology residents, there is a conspicuous lack of evidence supporting the integration of CBCT education within dental student curricula. The current CBCT training is fragmented across various courses, lacking a dedicated and cohesive approach for dental students. This gap in the educational framework prompted the formulation of my eight research questions, which aim to advance the understanding and implementation of CBCT technology and training for dental students. These questions represent a crucial step forward in the cumulative process of discovery, seeking to bridge the existing educational void and enhance the competency of future dental professionals in utilizing advanced imaging technologies.

Recurring themes were highlighted, such as enhanced diagnostic accuracy and the pivotal role of CBCT in treatment planning. This chapter critiqued the current insufficient training provided to pre-doctoral students, revealing significant gaps and inconsistencies in CBCT curriculum integration. The barriers to effective CBCT education were discussed, including faculty calibration, interdisciplinary collaboration, and leadership investment in advancing technology. Through a comprehensive search strategy and data extraction process, the review consolidated findings from various studies, underscoring the urgency to improve CBCT instruction for pre-doctoral dental students. Emphasis was placed on the need for radiologists to lead educational initiatives to minimize misdiagnosis and potential legal repercussions post-graduation, ultimately recommending

a more structured and intensive CBCT training program at the pre-doctoral level. In the next chapter, a qualitative research design was used to gather the CBCT perceptions of radiology leaders in the Midwest by conducting a thorough interview.

CHAPTER 3

RESEARCH DESIGN AND METHODS

Introduction

This chapter outlines the qualitative research design and methods employed to explore the perceptions of radiology leaders in Midwest dental schools regarding the integration of Cone Beam Computed Tomography (CBCT) education into pre-doctoral curricula. The study aimed to identify barriers and facilitators to incorporating CBCT education, assess the perceived necessity of CBCT training for fourth-year dental students, and evaluate the impact of CBCT on diagnostic accuracy, clinical efficiency, and legal risk management.

Research Design

The study utilized an interpretive qualitative research design, which is well-suited for understanding the subjective experiences and perspectives of individuals. This approach allowed for an in-depth exploration of the meanings and interpretations that radiology leaders assign to their experiences with CBCT education.

Participants

The participants in this study were ten radiology leaders from various Midwest dental schools. These individuals were selected based on their expertise and leadership roles in radiology education. The selection process aimed to ensure a diverse representation of perspectives across different institutions.

Data Collection

Data were collected through semi-structured interviews conducted face-to-face at the Annual Radiology Meeting in Hawaii. The interviews were designed to elicit detailed responses about the participants' experiences and perceptions of CBCT education. The validity of the interview questions was established by using content validity and triangulation methods with the assistance of a radiology expert, Enrique Platin. The questionnaire was further validated by statistician Aaron Bauner using IBM SPSS29 software. Feedback from healthcare expert Dr. Sharon Aka at Andrews University and statistician Aaron Bauner at the University of Michigan, Ann Arbor, led to refinements in the interview questions.

A questionnaire was used for data collection (Appendix A), which included questions about the availability of CBCT technology at each dental school, the number of CBCT didactic and clinical teaching hours for fourth-year dental students, and whether CBCT was provided for guided surgery, endodontics, and implant surgery. Additionally, leader perceptions of the readiness of fourth-year dental students to employ CBCT utilization were evaluated.

Ethical Considerations

The study applied for and received institutional research board (IRB) approval from Andrews University (Appendices B and C). Informed consent was obtained from all participants (Appendix B), ensuring that they were volunteers and that their anonymity was assured. Participants were informed that they could stop answering questions at any point in time. Participant information was protected in an encrypted computer and was not shared with any third party. Random numbers were assigned to the ten interviewees

to de-identify their answers. To encourage responses, reminder emails were sent during the second, third, and fifth weeks, and a phone call was made during the seventh week to increase the response rate.

The data analysis process involved several steps to ensure a thorough and accurate interpretation of the interview responses. The interviews were transcribed verbatim, and the transcripts were analyzed using thematic analysis. This method involved coding the data to identify recurring themes and patterns related to the research questions.

Thematic Analysis

Thematic analysis was conducted in several stages:

1. Familiarization with the data: The researcher read and re-read the transcripts to become deeply familiar with the content.
2. Generating initial codes: Key phrases and sentences were highlighted, and initial codes were assigned to segments of the data that were relevant to the research questions.
3. Searching for themes: The initial codes were grouped into broader themes that captured the essence of the participants' responses.
4. Reviewing themes: The themes were reviewed and refined to ensure they accurately represented the data and were distinct from one another.
5. Defining and naming themes: Each theme was clearly defined and given a descriptive name that encapsulated its core meaning.

Use of Visual Aids

To enhance the presentation of the findings, a bar graph was used to visually represent the frequency of themes identified in the interview responses. This visual aid

provided a clear and concise summary of the key themes, making it easier to interpret the data.

Conclusion

The qualitative research design and methods employed in this study provided a comprehensive understanding of the perceptions of radiology leaders regarding CBCT education. The use of thematic analysis allowed for the identification of key themes and patterns, offering valuable insights into the barriers and facilitators to integrating CBCT education into pre-doctoral curricula. The findings from this study have important implications for enhancing CBCT education and ultimately improving diagnostic accuracy and clinical efficiency in dental practice.

CHAPTER 4

RESULTS

Introduction to the Results

Chapter 4 presents the findings on the perceptions of radiology leaders in Midwest dental schools regarding the use of CBCT and its implications for clinical practice. The evaluation was based on eight qualitative research questions (see Appendix A), which guided face-to-face interviews with ten radiology leaders. To ensure confidentiality, all data were de-identified and anonymized, following the special request of eight participants. As outlined in Chapter 3, personal information was kept anonymous by assigning random numbers to each respondent. The de-identified data were securely stored in an encrypted computer at the Andrews University School of Leadership for three years to protect the privacy of all participants. In this results section, a comprehensive outline derived from the primary research questions will be delineated with the corresponding sub-questions. Additionally, the emergent themes associated with each research question and sub-question will be categorized and analyzed. Table 2 outlines the questions and the sub-questions asked of each participant.

Table 2

Outline of Research Questions and Sub-Questions

Research Questions	Sub-Questions
1. Understanding the reasons for the lack of CBCT education in Midwest dental schools.	
2. Assessing the necessity of teaching CBCT to fourth-year dental students.	a. Why or why not?
3. Identifying the key components and skills essential for CBCT education.	a. What specific skills should students acquire?
4. Determining the most effective teaching methods for CBCT education.	
5. Evaluating the current level of CBCT knowledge and skills among fourth-year dental students.	
6. Gathering suggestions for improving CBCT education.	
7. Identifying the challenges in teaching CBCT education.	a. How do you address issues related to the cost of the CBCT technology? b. How do you address the issues related to the accessibility of the CBCT technology?
8. Exploring the personal experiences of radiology leaders with integrating CBCT into their practice and its impact on their clinical work.	

The comprehensive outline (Table 2) provided a structured approach to understanding the multifaceted perspectives of radiology leaders on CBCT education and the practical implications based on the research questions and sub-questions. The research questions and sub-questions were designed to explore various aspects of CBCT education. These included: (a) understanding the reasons for the lack of CBCT education in Midwest dental schools, (b) assessing the necessity of teaching CBCT to fourth-year dental students, (c) identifying the key components and skills essential for CBCT education, (d) determining the most effective teaching methods for CBCT education, (e) evaluating the current level of CBCT knowledge and skills among fourth-year dental students, (f) gathering suggestions for improving CBCT education, (g) identifying the challenges in teaching CBCT, including issues related to cost and accessibility of CBCT technology, and (h) exploring the personal experiences of radiology leaders with integrating CBCT into their practice and its impact on their clinical work.

All ten participant responses were narrated and described clearly for each question with a comprehensive analysis and interpretation of the research questions and sub-questions. A detailed narration of the ten responses for each question, covering eight questions, is provided. Additionally, an in-depth overall analysis and interpretation of each research question has been meticulously conducted.

Responses to Survey Questions

Question 1: Understanding the Reasons for the Lack of CBCT Education in Midwest Dental Schools

Respondent 0: Many radiology leaders lack formal training in CBCT technology, which became prevalent after the 1990s. Additionally, CBCT is not explicitly mandated by the Commission on Dental Accreditation (CODA) for pre-doctoral students.

Respondent 1: Radiology leaders are overburdened with clinical responsibilities and teaching commitments, often exceeding four courses per year. The COVID-19 pandemic further diminished their capacity to innovate in educational curricula.

Respondent 2: CBCT education is dispersed across various clinical courses, and consolidating this information into a cohesive CBCT course is time-consuming and requires approval from the curriculum committee and faculty senate.

Respondent 3: CBCT education is typically taught in post-doctoral residency programs, and the CODA does not clearly define CBCT education in pre-doctoral programs.

Respondent 4: School administrators, curriculum committees, and faculty assemblies have not yet recognized the significance of CBCT education, hindering its integration into the curriculum.

Respondent 5: CBCT education is beyond the scope of dental education for pre-doctoral students, and many radiology leaders lack the expertise to teach CBCT technology comprehensively.

Respondent 6: Radiologists do not receive bonuses for teaching CBCT technology to novice dental students, and they fear that their private practice income will decrease if they share their expertise.

Respondent 7: University leadership does not provide adequate support for incorporating CBCT education into the curriculum. Proposals for CBCT courses have been rejected, citing concerns about overloading the student learning experience.

Respondent 8: Radiology leaders are preoccupied with administrative responsibilities and teaching both pre-doctoral and post-doctoral radiology courses, leaving little time to develop and integrate new educational content.

Respondent 9: Radiology leaders struggle to convince the dean of the importance of CBCT education and fail to effectively communicate the financial benefits of CBCT technology.

Question 1: Analysis and Interpretation

The primary reasons for the lack of CBCT education in Midwest dental schools are multifaceted. A significant factor is the lack of formal training among radiology leaders, as CBCT technology became prevalent only after the 1990s. This gap in training is compounded by the absence of explicit mandates from the CODA for pre-doctoral students, leading some leaders to deem CBCT education unnecessary.

Additionally, radiology leaders are often overburdened with clinical responsibilities and teaching commitments, leaving insufficient time to develop and integrate new educational content. The COVID-19 pandemic exacerbated this issue by imposing unrealistic expectations on radiology leaders to generate revenue through radiologic procedures, further diminishing their capacity to innovate in educational curricula.

Institutional support and recognition of the significance of CBCT education are also lacking. School administrators, curriculum committees, and faculty assemblies have not prioritized CBCT education, hindering its integration into the curriculum. Furthermore, the process of consolidating dispersed CBCT education across various clinical courses into a cohesive course is time-consuming and requires approval from multiple committees.

Financial constraints and the fear of decreased private practice income also play a role. Radiologists are reluctant to share their expertise in CBCT technology without

receiving bonuses, and they often hold CBCT technology closely to generate additional income through private practice and consultation.

Question 2: Assessing the Necessity of Teaching CBCT to Fourth-Year Dental Students

Respondent 0: Yes, teaching CBCT is necessary for accurately diagnosing bone height, bone width, and angulation of the mandible before implant placement, as well as for identifying the number and shape of canals before endodontic procedures.

Respondent 1: Yes, it equips students with the necessary skills to make accurate diagnoses in private practice or hospital settings. The institution uses five CBCT machines to teach the fundamentals of CBCT technology.

Respondent 2: Yes, it prepares students to utilize CBCT technology in current clinical settings and apply this knowledge in their future practices. Numerous studies have demonstrated the value of CBCT in all clinical specialties and general dentistry.

Respondent 3: No, teaching CBCT is not necessary as students already have a substantial workload to meet graduation requirements. Adding CBCT education would overburden them and negatively impact their learning experience.

Respondent 4: Yes, integrating 3-D diagnostic imaging tools into their education will provide training on state-of-the-art technology, preparing them for successful private practice.

Respondent 5: Yes, it trains students to use advanced diagnostic imaging technology in their future private practices. CBCT technology can be seamlessly integrated with artificial intelligence for diagnosis and treatment planning.

Respondent 6: Yes, the standard of patient care has evolved to incorporate new technologies such as CBCT and 3-D imaging for diagnosing pathologies and surgical planning. Without CBCT, there is a higher risk of surgical errors.

Respondent 7: Yes, it enhances diagnostic and treatment-planning skills in the clinic, integrating anatomical, physiological, and digital interpretation of 3-D imaging.

Respondent 8: Yes, it is essential to align teaching quality with current CBCT technology for disease detection. Radiology leaders should first become proficient in CBCT technology before teaching it to students.

Respondent 9: Yes, CBCT technology has revolutionized diagnostic and patient care practices, becoming the state-of-the-art tool for diagnosis and surgical planning.

Question 2: Analysis and Interpretation

The consensus among respondents was that teaching CBCT to fourth-year dental students is necessary. CBCT technology is crucial for accurately diagnosing bone height, bone width, and angulation of the mandible before implant placement, as well as for identifying the number and shape of canals before endodontic procedures. Proper use of CBCT can prevent complications in implant surgeries and ensure precise treatment planning.

Teaching CBCT equips students with the necessary skills to make accurate diagnoses in private practice or hospital settings, preparing them to utilize CBCT technology in current clinical settings and to apply this knowledge in their future practices. Numerous studies have demonstrated the value of CBCT in all clinical specialties as well as in general dentistry for patient care and diagnosis.

However, one respondent believes that teaching CBCT is not necessary due to the substantial workload already faced by fourth-year dental students. Adding CBCT education to their curriculum would overburden them and negatively impact their learning experience.

Question 3: Identifying the key Components and Skills Essential for CBCT Education

Respondent 0: Students should acquire the ability to download and open CBCT files, trace the mandibular canal, and evaluate sinuses before implant surgery. They should also develop skills in assessing endodontic procedures, periodontal bone loss, TMJ diseases, and basic pathology detection.

Respondent 1: Students should be introduced to CBCT landmarks in their first-year anatomy courses and be proficient in identifying specific anatomical landmarks, detecting pathologies on CBCT scans, and providing differential diagnoses by their fourth year.

Respondent 2: Students should possess a comprehensive understanding of CBCT and its applications in both medicine and dentistry. They should be proficient in providing differential diagnoses and planning implant surgeries using CBCT technology.

Respondent 3: Interested students can take an optional CBCT educational course through the Continuing Education (CE) department. They also have the opportunity to enroll in CBCT CE after graduation.

Respondent 4: An organized syllabus and well-trained CBCT experts or recent radiology graduates are essential. Students must develop proficiency in planning implant surgeries and evaluating nerves and sinuses before surgical procedures using CBCT scans.

Respondent 5: Students should have a strong foundation in anatomy and pathology to correlate human body pathologies with CBCT imaging components. A solid understanding of 2-D imaging is essential for comprehending 3-D imaging in CBCT technology.

Respondent 6: Students must have a basic understanding of normal human anatomy and a sound grasp of 2-D human anatomy on panoramic images. Pre-requisite training in radiology, pathology, implant surgery, and digital anatomy courses are essential.

Respondent 7: Students should learn how to trace the mental and mandibular canals and evaluate sinuses for implant planning and the extraction of impacted teeth. They should also understand the medical and legal implications of not using CBCT in their practice.

Respondent 8: Students should be able to distinguish between normal anatomy and pathology and learn how to interpret CBCT data for pathology detection and surgical purposes at a basic level.

Respondent 9: Essential components include foundational knowledge of normal anatomy and the ability to identify 3-D imaging pathology. Education should be delivered at both the pre-clinical and clinical levels by two radiology leaders.

Question 3: Analysis and Interpretation

The key components and skills essential for CBCT education include a comprehensive understanding of CBCT technology and its applications in both medicine and dentistry. Students should acquire the ability to download and open CBCT files, trace the mandibular canal, and evaluate sinuses before implant surgery. They should also

develop skills in assessing endodontic procedures, periodontal bone loss, TMJ diseases, and basic pathology detection.

A strong foundation in anatomy and pathology is crucial for correlating human body pathologies with CBCT imaging components. Students should be proficient in identifying specific anatomical landmarks, detecting pathologies on CBCT scans, and providing differential diagnoses for various pathologies. This comprehensive understanding is essential for their clinical competence.

Some respondents suggest that interested students can take optional CBCT educational courses through the CE department or enroll in CBCT CE after graduation.

Question 4: Determining the Most Effective Teaching Methods for CBCT Education

Respondent 0: Hands-on training is the most effective teaching method for CBCT education. Colleagues at other institutions successfully use hands-on training to teach CBCT to oral and maxillofacial surgery students.

Respondent 1: The "Tell-Show-Do" method is the most effective approach. This method involves explaining the concept (Tell), demonstrating the procedure (Show), and allowing students to perform the task themselves (Do).

Respondent 2: Hands-on training and case discussions using CBCT software are effective teaching methods. This technology requires a solid foundation in diagnosis, treatment planning, and follow-up for major procedures.

Respondent 3: Hands-on CBCT training using real patient cases is provided for post-doctoral residents and candidates enrolled in CBCT CE.

Respondent 4: Case discussions are the most effective teaching method. This approach allows students to engage in critical thinking, analyze each case holistically, and integrate knowledge from both dental and medical sciences.

Respondent 5: Case discussions are the most effective teaching method. This approach allows students to follow the RACI chart (R = responsibility, A = accountability, C = consulted, I = informed) for the cases they are assigned.

Respondent 6: A systematic approach to teaching anatomy in the first year, pathology in the second year, and surgery in the third and fourth years is the most effective method. This approach provides good clinical exposure and a comprehensive patient experience.

Respondent 7: Case discussions and group learning are the most effective teaching methods. These methods allow students to ask questions and learn from each other, and when they have further inquiries, they can consult the radiology leader and the clinic instructor.

Respondent 8: Learning by doing is the most effective teaching method. Allowing students to handle actual patient cases makes the learning experience more personal and relatable.

Respondent 9: Hands-on training and case-based discussions are the most effective teaching methods. These methods allow students to apply theoretical knowledge in practical settings, enhancing their learning experience.

Question 4. Analysis and Interpretation

The most effective teaching methods for CBCT education include hands-on training, case discussions, and the “Tell-Show-Do” method. Hands-on training allows

students to apply theoretical knowledge in practical settings, enhancing their learning experience. Case discussions enable students to engage in critical thinking, analyze each case holistically, and integrate knowledge from both dental and medical sciences.

The "Tell-Show-Do" method involves explaining the concept (Tell), demonstrating the procedure (Show), and allowing students to perform the task themselves (Do). This method is highly appreciated by students for its value in enhancing their planning and accuracy in clinical practice.

A systematic approach to teaching anatomy in the first year, pathology in the second year, and surgery in the third and fourth years is also effective. This approach provides good clinical exposure and a comprehensive patient experience before graduation.

Question 5: Evaluating the Current Level of CBCT Knowledge and Skills Among Fourth-Year Dental Students

Respondent 0: The institution does not currently teach CBCT to fourth-year dental students, so there is no system in place to assess their level of CBCT knowledge and skills.

Respondent 1: The level of CBCT knowledge and skills is assessed through a radiology competency exam administered in the second year, which includes five CBCT-related questions out of a total of 35.

Respondent 2: The level of CBCT knowledge and skills is assessed by selecting two cases that apply CBCT technology in their radiology competency exams. However, this assessment method is recognized as unreliable due to the lack of a dedicated CBCT course.

Respondent 3: The institution does not assess the level of CBCT knowledge and skills among fourth-year dental students, as CBCT education is not part of their curriculum.

Respondent 4: The level of CBCT knowledge and skills is assessed through two exams, two assignments on CBCT technology and its applications, and ten hands-on cases covering pathology, TMJ disorders, nerve tracing, endodontic evaluations, and implant surgery planning. An evaluation form is used to assess performance in each category, and XCOM is employed for comprehensive assessment.

Respondent 5: The level of CBCT knowledge and skills is assessed using a competency-based format with categories of pass or fail, ensuring that students meet the required standards.

Respondent 6: The level of CBCT knowledge and skills is assessed through a clinical competency exam, on which 5% of the questions are on CBCT-related pathology, anatomy, and implant planning. The grading system categories are satisfactory, needs improvement, and repeat.

Respondent 7: There is no system to assess the level of CBCT knowledge and skills among fourth-year dental students because CBCT is not taught to them.

Respondent 8: There is no robust system to assess the level of CBCT knowledge and skills among fourth-year dental students. However, four CBCT-related questions are included in the radiology final exam to gauge some level of CBCT knowledge and skills.

Respondent 9: The level of CBCT knowledge and skills is assessed through weekly CBCT laboratory sessions during the Fall semester. Students are graded based on evidence-based learning and competency.

Question 5: Analysis and Interpretation

The evaluation of CBCT knowledge and skills among fourth-year dental students varies across institutions. Some institutions do not teach CBCT currently to fourth-year dental students, so there is no system in place to assess their level of CBCT knowledge and skills. Other institutions assess CBCT knowledge and skills through radiology competency exams, clinical competency exams, and weekly CBCT laboratory sessions.

Assessment methods include exams with CBCT-related questions, assignments on CBCT technology and its applications, and hands-on cases covering various aspects of CBCT technology. Competency-based formats with pass or fail categories are also used to ensure that students meet the required standards.

Question 6: Gathering Suggestions for Improving CBCT Education

Respondent 0: Integrate CBCT training into various courses such as surgery, prosthodontics, and periodontics. Introducing CBCT education to third-year students would also be beneficial.

Respondent 1: Appoint a dedicated CBCT expert who can teach CBCT courses using a structured syllabus, ensuring comprehensive instruction in both theoretical and clinical applications.

Respondent 2: Convince the deans of the significance of CBCT education for accurate diagnoses and treatments. Installing new CBCT machines in every department would benefit patients, enhance students' learning experiences, and foster faculty collaboration.

Respondent 3: Provide hands-on training with actual patients and use a standard CBCT software to train and calibrate students, residents, and faculty.

Respondent 4: Increase the number of patient cases from 10 to 20 and schedule a dedicated clinic time for two hours each week during the winter semester for focused education on CBCT diagnosis and treatment planning.

Respondent 5: Increase the CBCT teaching percentage from 2% to 30% and integrate CBCT education into other courses such as implant surgery and pathology.

Respondent 6: Radiology leaders should receive additional bonuses for teaching CBCT, as it requires over 20 hours of extra work per week. Integrate CBCT technology into all departments and courses within the curriculum.

Respondent 7: Develop a structured syllabus and an assessment or evaluation system to teach CBCT education to fourth-year dental students.

Respondent 8: Collaborate with the clinic dean, faculty assembly, curriculum committee, and radiology leaders to develop a structured CBCT course. Integrate CBCT technology into all required courses in the curriculum.

Respondent 9: Acquire at least four dedicated CBCT machines and 25 software licenses to allow fourth-year dental students to practice and complete their clinical cases more flexibly.

Question 6: Analysis and Interpretation

The main challenges in teaching CBCT education include the lack of formal training among radiology leaders, insufficient budget to hire dedicated CBCT experts, and inadequate training for students. Financial constraints and the high cost of CBCT machines and software licenses also pose significant challenges.

Lack of cooperation and collaboration among departments, as well as the reluctance of insurance companies to accept CBCT procedures due to the absence of

assigned codes, further complicate the situation. Radiology leaders are often overworked and burned out, leading to job dissatisfaction and attrition.

To address these challenges, increased funding, better support and resources for radiology leaders, and equitable access to CBCT technology for all students are necessary.

Question 7: Identifying the Challenges in Teaching CBCT Education

Respondent 0: The primary challenge is the lack of formal training in CBCT. Other challenges include the difficulty and expense of finding well-trained radiology leaders and interdepartmental issues hindering collaboration.

Respondent 1: The lack of a dedicated CBCT expert and insufficient budget to hire one. Students often hesitate to use CBCT machines due to inadequate training.

Respondent 2: Lack of cooperation and collaboration among departments. Funding constraints and negligence from school leadership make it difficult to install new machines in every department.

Respondent 3: Lack of cooperation and collaboration among departments. Insurance companies do not accept CBCT procedures due to the absence of assigned codes, requiring patients to pay out-of-pocket.

Respondent 4: Significant disconnection when dental students transition from their third to fourth years, as they lack prior knowledge of CBCT technology. Insurance companies do not cover CBCT procedures, requiring patients to pay out-of-pocket.

Respondent 5: Limited funding from administrators to run the CBCT clinic. Students must pay additional fees to learn CBCT technology, resulting in unequal access.

Respondent 6: Significant amount of time required to prepare CBCT presentations, clinical cases, and follow-ups with patients. Radiology leaders are often overworked and burned out.

Respondent 7: Lack of familiarity with the technology among post-doctoral residents, leading to numerous questions. High cost of CBCT machines and their primary use for intramural practice limits accessibility.

Respondent 8: Lack of sufficient funding to train all students on the two available CBCT machines. Need to purchase 174 CBCT software packages for each student to facilitate hands-on training.

Respondent 9: High costs of machines and software licenses. Limited access for pre-doctoral fourth-year students as the machines are reserved for post-doctoral students.

Question 7: Analysis and Interpretation

The main challenges in teaching CBCT include the lack of formal training among radiology leaders, insufficient budget to hire dedicated CBCT experts, and inadequate training for students. Financial constraints and the high cost of CBCT machines and software licenses also pose significant challenges.

Lack of cooperation and collaboration among departments, as well as the reluctance of insurance companies to accept CBCT procedures due to the absence of assigned codes, further complicate the situation. Radiology leaders are often overworked and burned out, leading to job dissatisfaction and attrition.

To address these challenges, increased funding, better support and resources for radiology leaders, and equitable access to CBCT technology for all students are necessary.

Question 8: Exploring the Personal Experiences of Radiology Leaders with Integrating CBCT into Their Practice and its Impact on Their Clinical Work

Respondent 0: Fully integrated CBCT with the assistance of oral surgeons and ENT specialists. CBCT reports are generated externally or by the oral surgeon before any surgical procedure, streamlining workflow and enhancing the quality of care.

Respondent 1: Integrating CBCT in 2009 significantly improved patient care by utilizing advanced CBCT technology for all patients. This integration led to a 60% reduction in time and resources, increasing practice revenue and reducing unnecessary expenses for patients.

Respondent 2: Integrating two CBCT machines significantly enhanced the ability to make accurate diagnoses for pathologies and perform facial reconstruction procedures. The adoption of CBCT technology increased revenue by 50%.

Respondent 3: Integrating CBCT technology saved time and increased revenue by significantly enhancing patient care and satisfaction. Over the past five years, CBCT improved the precision of diagnoses and treatments.

Respondent 4: Integrating CBCT technology has been transformative, enhancing patient education and reducing patient-doctor interaction time by 60%. It improved diagnostic precision and treatment outcomes, leading to increased patient satisfaction and trust.

Respondent 5: Integrating CBCT technology has been transformative, with a 97% success rate in implant surgery planning. Patient satisfaction rate and clinical efficiency improved by 72%.

Respondent 6: Integrating CBCT technology has been transformative compared to practice methods from forty years ago. It reduced treatment time and resources for

surgical planning and nerve tracing, decreased the cost of care, and increased the success rate.

Respondent 7: Integrating CBCT technology provided employment for two staff members and increased clinical efficiency by 75% over the past three years. CBCT is used as the gold standard for diagnosing pathology, planning implant surgeries, and performing complex head and neck surgeries.

Respondent 8: Integrating CBCT technology significantly increased clinical work efficiency and reduced stress by 72%. It enabled the performance of complex procedures more easily, improving patient care and workflow.

Respondent 9: Integrating CBCT technology significantly enhanced patient-centered care for both surgical and non-surgical cases. It improved clinical efficiency by 78%, reducing the time required for surgical planning from three hours to just five minutes.

Question 8: Analysis and Interpretation

Integrating CBCT technology into clinical practice has been transformative for radiology leaders. It has significantly improved patient care by enhancing diagnostic precision and treatment planning. The use of CBCT technology has led to increased clinical efficiency, reduced treatment time and resources, and higher patient satisfaction and trust.

CBCT technology has also increased practice revenue by reducing unnecessary expenses for patients and improving the success rate of implant surgery planning. The integration of CBCT technology has streamlined workflow, provided employment opportunities, and enhanced the overall quality of care provided to patients.

Summary of Question Responses

The responses highlight the importance of CBCT education for fourth-year dental students, the challenges faced in integrating CBCT education into the curriculum, and the transformative impact of CBCT technology on clinical practice. Addressing the identified challenges and implementing the suggested improvements can enhance CBCT education and ultimately improve patient care.

Following this comprehensive analysis and interpretation of each research question, a secondary structure is presented categorizing and analyzing the emergent themes associated with each research question and sub-question in Table 3 and Figure 4.

Table 3

Analysis of Emergent Themes Observed in Responses

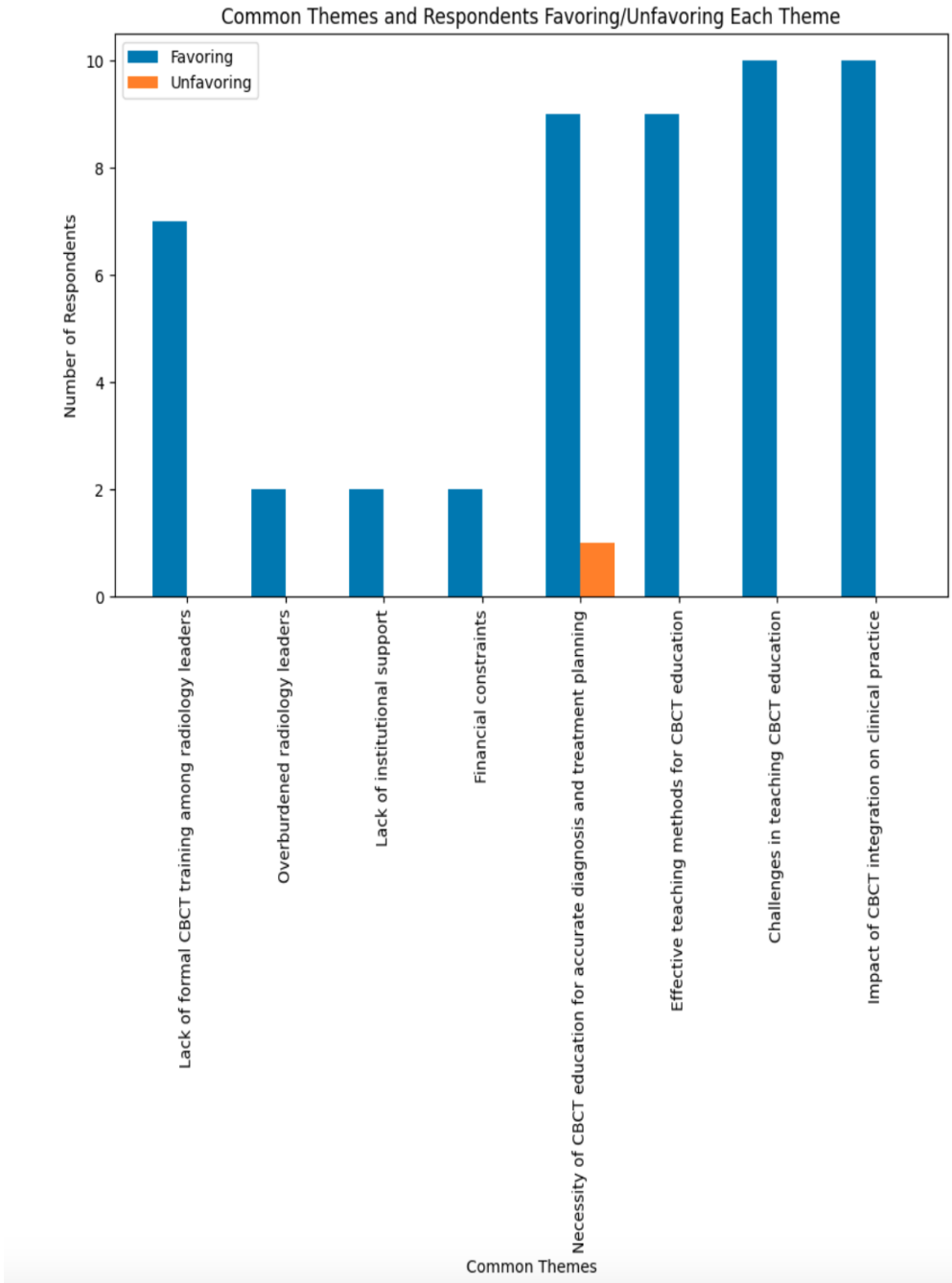
Common Themes	Respondents Favorable to Theme	Respondents Unfavorable to Theme	Representative Quotes	Categories	Analysis
Lack of formal CBCT training among radiology leaders	0, 1, 3, 5, 6, 8, 9		Many radiology leaders lack formal training in CBCT technology.	Training, Education	The lack of formal training is a significant barrier to integrating CBCT education into dental curricula.
Overburdened radiology leaders	1, 8		Radiology leaders are overburdened with clinical responsibilities and teaching commitments.	Workload, Responsibilities	High workload limits the capacity of radiology leaders to innovate and integrate new educational content.
Lack of institutional support	4, 7	-	University leadership does not provide adequate support for incorporating CBCT education into the curriculum.	Institutional Support, Administration	Insufficient support from university leadership hinders the integration of CBCT education.
Financial constraints	6, 9	-	Radiologists do not receive bonuses for teaching CBCT technology.	Financial, Incentives	Financial incentives and constraints play a role in the reluctance to teach CBCT technology.
Necessity of CBCT education for accurate diagnosis and treatment planning	0, 1, 2, 4, 5, 6, 7, 8, 9	3	Teaching CBCT is necessary for accurately diagnosing bone height, bone width, and angulation of the mandible before implant placement.	Curriculum, Clinical Skills	There is a strong consensus on the necessity of CBCT education for accurate diagnosis and treatment planning, despite concerns about student workload.

Table 3, continued

Common Themes	Respondents Favorable to Theme	Respondents Unfavorable to Theme	Representative Quotes	Categories	Analysis
Effective teaching methods for CBCT education	0, 1, 2, 3, 4, 5, 6, 7, 8, 9	-	Hands-on training is the most effective teaching method for CBCT education.	Teaching Methods, Pedagogy	Hands-on training, case discussions, and the "Tell-Show-Do" method are identified as effective teaching methods.
Challenges in teaching CBCT education	0, 1, 2, 3, 4, 5, 6, 7, 8, 9	-	The primary challenge is the lack of formal training in CBCT.	Challenges, Barriers	Multiple challenges, including lack of formal training, financial constraints, and interdepartmental issues, are identified.
Impact of CBCT integration on clinical practice	0, 1, 2, 3, 4, 5, 6, 7, 8, 9	-	Integrating CBCT technology has been transformative, enhancing patient education and reducing patient-doctor interaction time by 60%.	Clinical Practice, Technology Integration	The integration of CBCT technology has significantly improved clinical efficiency, patient care, and diagnostic precision.

Figure 4

Common Themes and Respondents Favorable/Unfavorable to Each Theme



Analysis and Interpretation of Themes

The detailed analysis and interpretation of themes from Table 3 and Figure 4 reveal critical insights into integrating CBCT education in dental curricula. The themes were categorized based on respondent feedback, highlighting both those favorable and unfavorable to the perspectives, including representative quotes, and analyzing each theme.

Lack of Formal CBCT Training Among Radiology Leaders

This theme is widely recognized, with seven respondents (0, 1, 3, 5, 6, 8, 9) favorable to it. The representative quote, "Many radiology leaders lack formal training in CBCT technology," underscores the significant barrier posed by the absence of formal training. The analysis emphasizes that this lack of training is a critical issue that needs to be addressed to facilitate the adoption of CBCT education. The theme falls under the categories of Training and Education, indicating the necessity for structured training programs to bridge the knowledge gap and ensure effective teaching of CBCT technology.

Overburdened Radiology Leaders

Two respondents (1, 8) favor this theme, highlighting the workload and responsibilities of radiology leaders. The quote, "Radiology leaders are overburdened with clinical responsibilities and teaching commitments," reflects the high workload that limits their capacity to innovate and integrate new educational content. The analysis points out that this workload issue is a significant impediment to the adoption of CBCT education, as it restricts leader ability to develop and implement new curricula.

Lack of Institutional Support

This theme was favored by two respondents (4, 7), with the quote, "University leadership does not provide adequate support for incorporating CBCT education into the curriculum," illustrating the lack of institutional backing. The categories of Institutional Support and Administration are highlighted, indicating that insufficient support from university leadership hinders the integration of CBCT education. The analysis stresses the need for institutional commitment and resources to incorporate CBCT education effectively.

Financial Constraints

Two respondents (6, 9) favored this theme, with the quote, "Radiologists do not receive bonuses for teaching CBCT technology," pointing to the financial barriers. The categories of Financial and Incentives are relevant here, as financial incentives and constraints significantly influence the willingness of radiologists to teach CBCT technology. The analysis notes that the lack of bonuses and the high cost of CBCT machines and software licenses are notable barriers, affecting the motivation of radiologists to invest additional time and effort.

Necessity of CBCT Education for Accurate Diagnosis and Treatment Planning

This theme has strong support, with nine respondents (0, 1, 2, 4, 5, 6, 7, 8, 9) favorable to it, and one respondent (3) unfavorable to it due to workload concerns. The quote, "Teaching CBCT is necessary for accurately diagnosing bone height, bone width, and angulation of the mandible before implant placement," emphasizes the critical importance of CBCT technology in clinical practice. The categories of Curriculum and

Clinical Skills are highlighted, with the analysis underscoring the necessity of CBCT education for enhancing diagnostic accuracy and treatment planning.

Effective Teaching Methods for CBCT Education

This theme is unanimously favored by nine respondents (0, 1, 2, 4, 5, 7, 8, 9), with the quote, "Hands-on training is the most effective teaching method for CBCT education," reflecting the preferred teaching methods. The categories of Teaching Methods and Pedagogy are relevant, with the analysis identifying hands-on training, case discussions, and the "Tell-Show-Do" method as the most effective approaches. These methods enhance the practical application of theoretical knowledge, improving students' learning experiences.

Challenges in Teaching CBCT Education

All ten respondents (0, 1, 2, 3, 4, 5, 6, 7, 8, 9) recognized this theme, with the quote, "The primary challenge is the lack of formal training in CBCT," highlighting the main barrier. The categories of Challenges and Barriers are pertinent, with the analysis identifying multiple challenges, including financial constraints and interdepartmental issues. Addressing these challenges is crucial for the successful integration of CBCT education.

Impact of CBCT Integration on Clinical Practice

This theme is unanimously favored by all ten respondents (0, 1, 2, 3, 4, 5, 6, 7, 8, 9), with the quote, "Integrating CBCT technology has been transformative, enhancing patient education and reducing patient-doctor interaction time by 60%," illustrating the positive impact. The categories of Clinical Practice and Technology Integration are

highlighted, with the analysis emphasizing the transformative impact of CBCT integration on clinical efficiency, patient care, and diagnostic precision.

Figure 4 visually represents the distribution of respondent opinions on various themes, highlighting the high degree of agreement on the necessity and impact of CBCT education, the unanimous recognition of challenges, the lack of significant opposition, and the distribution of favorable respondents. The comprehensive analysis below provides a clear understanding of the emergent themes, respondent perspectives, and the overall consensus on the importance and challenges of CBCT education in dental curricula. The graph complements the table by visually representing the distribution of respondent opinions, highlighting the key points and areas of agreement.

Discussion of Common Themes

Graph 4 represents the distribution of respondents' opinions on various themes and highlights the following key points.

High Agreement on Necessity and Impact

The themes of (a) the necessity of CBCT education for accurate diagnosis and treatment planning, and (b) the impact of CBCT integration on clinical practice, have the highest number of respondents favorable to them. This indicates a strong consensus on the importance of CBCT education and its positive impact on clinical practice. The necessity of CBCT education is underscored by its critical role in enhancing diagnostic accuracy and treatment planning, which are essential for successful clinical outcomes. Similarly, the impact of CBCT integration on clinical practice is highlighted by its transformative effects, such as improving clinical efficiency, patient care, and diagnostic precision.

Unanimous Challenges

All respondents recognized the challenges in teaching CBCT education, indicating a unanimous agreement on the barriers that need to be addressed. The primary challenge identified is the lack of formal training in CBCT technology, which is a significant impediment to its integration into dental curricula. Financial constraints and interdepartmental issues were also highlighted as major challenges. The recognition of these challenges underscores the need for comprehensive solutions to facilitate the integration of CBCT education. Addressing these barriers is crucial for the successful adoption of CBCT technology in dental education.

Lack of Opposition

There is no significant opposition noted in the identified themes, except for one respondent not favorable to the necessity of CBCT education due to workload concerns. This lack of opposition suggests a general agreement on the importance of the themes identified and the need to address the challenges. The absence of significant opposition indicates a broad consensus among respondents on the critical issues and the necessary steps to overcome them. This consensus is vital for driving forward the integration of CBCT education in dental curricula.

Distribution of Favorable Respondents

The distribution of respondents favorable to each theme varies, with some themes having more widespread support than others. For example, the necessity of CBCT education and the impact of CBCT integration have the highest number of favorable respondents, while themes like overburdened radiology leaders and lack of institutional support have fewer favorable respondents. This variation in support highlights the

differing levels of importance and urgency attributed to each theme by the respondents. It also reflects the diverse perspectives and experiences of the respondents regarding the integration of CBCT education.

Themes with no Unfavorable Respondents

Several themes, including lack of formal CBCT training, overburdened radiology leaders, lack of institutional support, financial constraints, effective teaching methods, challenges in teaching CBCT education, and impact of CBCT integration, have no unfavorable respondents. This indicates a general consensus on the importance and relevance of these themes. The absence of opposition to these themes highlights their critical role in the successful integration of CBCT education into dental curricula. It also underscores the need for targeted interventions to address these issues and facilitate the adoption of CBCT technology.

Upon analyzing the data presented in Table 3 and Figure 4 of the document, it is evident that several respondents did not provide feedback on specific themes. Specifically, for Theme 1, three respondents did not respond. For Themes 2 and 3, eight respondents did not provide feedback. Theme 4 had two respondents who did not respond, while Themes 5, 7, and 8 had no non-respondents, indicating full engagement with these themes. Theme 6 also had two respondents who did not provide feedback. This non-response could impact the overall analysis and interpretation of the data, as it may skew the representation of respondent perspectives. It is crucial to consider these non-responses when drawing conclusions and making recommendations based on the data, as they highlight areas where further investigation or clarification may be needed to ensure a comprehensive understanding of the respondents' views.

This comprehensive analysis provides a clear understanding of the emergent themes, respondent perspectives, and the overall consensus on the importance and challenges of CBCT education in dental curricula. The graph complements the table by visually representing the distribution of respondent opinions, highlighting the key points and areas of agreement. The detailed analysis and interpretation of the themes from Table 3 and Figure 4 offer valuable insights into the critical factors influencing the integration of CBCT education in dental curricula, emphasizing the need for structured training programs, institutional support, and effective teaching methods to overcome the identified challenges.

In the next chapter, a discussion section will provide a comprehensive analysis and interpretation of the research findings. the key results will be summarized, emphasizing the significant themes such as the necessity of CBCT education for accurate diagnosis and treatment planning, and the positive impact of CBCT integration on clinical practice. Existing literature will be surveyed and compared to highlight the study contributions. The practical implications for dental education and clinical practice will be discussed, and the challenges and barriers analyzed and identified, such as the lack of formal CBCT training and financial constraints, followed by proposing potential solutions. Additionally, reflection on the strengths and limitations of the study will occur, and suggestions proposed of areas for future research to further explore the integration of CBCT education in dental curricula.

CHAPTER 5

DISCUSSION

Introduction

This study aimed to explore the perceptions of radiology leaders regarding the integration of CBCT education into pre-doctoral dental curricula in the Midwest. The primary objectives were to (a) identify the barriers and facilitators to incorporating CBCT education, (b) assess the perceived necessity of CBCT training for fourth-year dental students, and (c) evaluate the impact of CBCT on diagnostic accuracy, clinical efficiency, and legal risk management. Chapter 5 provides an overview of the research design and sampling method used to determine eight findings. The findings reveal significant insights into the current state of CBCT education and its potential benefits and challenges. The integration of CBCT into dental education is crucial given the increasing reliance on advanced imaging technologies in modern dental practice.

A discussion of the findings based on the conceptual frameworks of Malcolm Knowles (1977a, 1977b) and Carl Rogers' (1969) learning theory is integrated. Five recommendations based on the findings are provided, along with researcher reflections and a conclusion. The discussion is structured as follows: (a) Research DESIGN AND SAMPLING, (b) Findings, (c) Themes and patterns in participant responses, (d) Areas of distinct disagreement among participants, (e) Disagreements among participants on overarching patterns and themes, (f) Discrepancies among results, (g) Deep reflections on

the findings, (h) Big picture on evidence of struggling to understand data, (i) Recommendations, (j) Recommendations for future research, (k) Researcher reflections, (l) Conclusion. To understand the methodology behind these findings, we first delve into the research design and sampling techniques employed in this study.

Research Design and Sampling

To lay the groundwork for our exploration, we much first understand the research design and sampling methods employed in this study. A qualitative research design was utilized and interpretive analysis to summarize key dataset features. Radiology leader perceptions of the CBCT curriculum were analyzed using frequency counts, with data processed through SPSS and Excel software.

Interview responses from ten radiology leaders at Midwest dental schools were recorded using interpretive analysis. The interviews, conducted in person at the Annual Radiology Meeting in Hawaii, were validated through content validity and triangulation methods by radiology expert Enrique Platin. With a clear understanding of the research design and sampling, we can now delve into the core findings of this study.

Findings

Lack of Formal Training in CBCT Technology

The findings from our research provide critical insights into the current state of CBCT education in Midwest dental schools. Many radiology leaders in Midwest dental schools lack formal training in CBCT technology, which became prevalent after the 1990s. This gap in training is a significant barrier to integrating CBCT education into pre-doctoral programs (Research Question 1).

Overburdened Radiology Leaders

Radiology leaders are often overwhelmed with clinical responsibilities and teaching commitments, which limits their capacity to innovate and integrate new educational content, such as CBCT, into the curriculum. The COVID-19 pandemic has exacerbated this issue by increasing their workload (Research Question 1).

Institutional Support and Recognition

There is a lack of institutional support and recognition for the significance of CBCT education. School administrators, curriculum committees, and faculty assemblies have not prioritized CBCT education, hindering its integration into the curriculum (Research Question 1).

Necessity of CBCT Education for Fourth-Year Dental Students

Teaching CBCT to fourth-year dental students is deemed necessary by most respondents. CBCT technology is crucial for accurately diagnosing bone height, bone width, and angulation of the mandible before implant placement, as well as for identifying the number and shape of canals before endodontic procedures (Research Question 2).

Key Components and Skills for CBCT Education

Essential components for CBCT education include a comprehensive understanding of CBCT technology, the ability to download and open CBCT files, trace the mandibular canal, and evaluate sinuses before implant surgery. Students should also develop skills in assessing endodontic procedures, periodontal bone loss, TMJ diseases, and basic pathology detection (Research Question 3).

Effective Teaching Methods for CBCT Education

The most effective teaching methods for CBCT education include hands-on training, case discussions, and the "Tell-Show-Do" method. These methods enhance students' learning experiences by allowing them to apply theoretical knowledge in practical settings and engage in critical thinking (Research Question 4).

Challenges in Teaching CBCT Education

The primary challenges in teaching CBCT education include the lack of formal training among radiology leaders, insufficient budget to hire dedicated CBCT experts, and inadequate training for students. Financial constraints and the high cost of CBCT machines and software licenses also pose significant challenges (Research Question 7).

Transformative Impact of CBCT Technology on Clinical Practice

Integrating CBCT technology into clinical practice has been transformative for radiology leaders. Patient care has been significantly improved by enhancing diagnostic precision and treatment planning, increased clinical efficiency, reduced treatment time and resources, and led to higher patient satisfaction and trust (Research Question 8).

Themes and Patterns in Participants' Responses

Analyzing the data revealed several recurring themes and patterns in the participants' responses. In analyzing the responses from the radiology leaders in Chapter 4, several themes and patterns emerged that provide a comprehensive understanding of the current state of CBCT education in Midwest dental schools. These themes and patterns reflect both areas of consensus and points of contention among the participants,

offering valuable insights into the challenges and opportunities for integrating CBCT education into dental curricula.

Lack of Formal Training in CBCT Technology

A significant theme was the lack of formal training in CBCT technology among radiology leaders. This gap in training is a critical barrier to integrating CBCT education into pre-doctoral programs. Many radiology leaders, having been trained before the widespread adoption of CBCT in the 1990s, lack the necessary expertise to teach this technology effectively. This deficiency underscores the urgent need for structured training programs to equip educators with the skills required to impart CBCT knowledge to their students.

Evidence:

- Respondent 0: “Many radiology leaders lack formal training in CBCT technology.”
- Respondent 1: “Radiology leaders are overburdened with clinical responsibilities and teaching commitments.”

Overburdened Radiology Leaders

Radiology leaders are often overwhelmed with clinical responsibilities and teaching commitments, which limits their capacity to innovate and integrate new educational content, such as CBCT, into the curriculum. The COVID-19 pandemic has exacerbated this issue by increasing their workload, further diminishing their capacity to develop and implement new curricula.

Evidence:

- Respondent 1: “Radiology leaders are overburdened with clinical responsibilities and teaching commitments.”
- Respondent 8: “Radiology leaders are preoccupied with administrative responsibilities and teaching both pre-doctoral and post-doctoral radiology courses.”

Lack of Institutional Support

There is a lack of institutional support and recognition for the significance of CBCT education. School administrators, curriculum committees, and faculty assemblies have not prioritized CBCT education, hindering its integration into the curriculum. Without institutional backing, efforts to incorporate CBCT education remain fragmented and ineffective.

Evidence:

- Respondent 4: “School administrators, curriculum committees, and faculty assemblies have not yet recognized the significance of CBCT education.”
- Respondent 7: “University leadership does not provide adequate support for incorporating CBCT education into the curriculum.”

Financial Constraints

Financial constraints and the high cost of CBCT machines and software licenses pose significant challenges to the integration of CBCT education. Insufficient budgets and the lack of financial incentives for radiology leaders are major barriers that need to be addressed to facilitate the adoption of CBCT education.

Evidence:

- Respondent 6: “Radiologists do not receive bonuses for teaching CBCT technology.”
- Respondent 9: “High costs of machines and software licenses.”

Necessity of CBCT Education for Accurate Diagnosis and Treatment Planning

There is a strong consensus on the necessity of CBCT education for accurate diagnosis and treatment planning. CBCT technology is crucial for diagnosing bone height, bone width, and angulation of the mandible before implant placement, as well as for identifying the number and shape of canals before endodontic procedures.

Evidence:

- Respondent 0: “Teaching CBCT is necessary for accurately diagnosing bone height, bone width, and angulation of the mandible before implant placement.”
- Respondent 1: “It equips students with the necessary skills to make accurate diagnoses in private practice or hospital settings.”

Effective Teaching Methods for CBCT Education

The most effective teaching methods for CBCT education include hands-on training, case discussions, and the “Tell-Show-Do” method. These methods enhance students’ learning experiences by allowing them to apply theoretical knowledge in practical settings and engage in critical thinking.

Evidence:

- Respondent 0: “Hands-on training is the most effective teaching method for CBCT education.”

- Respondent 1: “The ‘Tell-Show-Do’ method is the most effective approach.”

Challenges in Teaching CBCT Education

The primary challenges in teaching CBCT education include the lack of formal training among radiology leaders, insufficient budget to hire dedicated CBCT experts, and inadequate training for students. Financial constraints and the high cost of CBCT machines and software licenses also pose significant challenges.

Evidence:

- Respondent 0: “The primary challenge is the lack of formal training in CBCT.”
- Respondent 1: “The lack of a dedicated CBCT expert and insufficient budget to hire one.”

Impact of CBCT Integration on Clinical Practice

Integrating CBCT technology into clinical practice has been transformative for radiology leaders. It has significantly improved patient care by enhancing diagnostic precision and treatment planning. The use of CBCT technology has led to increased clinical efficiency, reduced treatment time and resources, and higher patient satisfaction and trust.

Evidence:

- Respondent 0: “Integrating CBCT technology has been transformative, enhancing patient education and reducing patient-doctor interaction time by 60%.”
- Respondent 1: “Integrating CBCT in 2009 significantly improved patient care by utilizing advanced CBCT technology for all patients.”

Key Components and Skills for CBCT Education

Essential components for CBCT education include a comprehensive understanding of CBCT technology, the ability to download and open CBCT files, trace the mandibular canal, and evaluate sinuses before implant surgery. Students should also develop skills in assessing endodontic procedures, periodontal bone loss, TMJ diseases, and basic pathology detection.

Evidence:

- Respondent 0: "Students should acquire the ability to download and open CBCT files, trace the mandibular canal, and evaluate sinuses before implant surgery."
- Respondent 1: "Students should be introduced to CBCT landmarks in their first-year anatomy courses."

Assessment of CBCT Knowledge and Skills

There is a distinct disagreement on how to assess the CBCT knowledge and skills of fourth-year dental students. Some respondents believe in comprehensive, competency-based assessments, while others rely on more traditional examination methods or do not assess CBCT skills at all due to the lack of a dedicated CBCT course.

Evidence:

- Respondent 4: "The level of CBCT knowledge and skills is assessed through two exams, two assignments on CBCT technology and its applications, and ten hands-on cases."
- Respondent 1: "The level of CBCT knowledge and skills is assessed through a radiology competency exam administered in the second year."

Integration of CBCT Education into the Curriculum

Significant disagreements were found on how to integrate CBCT education into the existing dental curriculum. Some respondents advocate for embedding CBCT training into various courses, while others suggest developing a standalone CBCT course or incorporating it into continuing education programs.

Evidence:

- Respondent 0: "Integrate CBCT training into various courses such as surgery, prosthodontics, and periodontics."
- Respondent 2: "Develop a structured syllabus and an assessment or evaluation system to teach CBCT education to fourth-year dental students."

Balancing Educational Value and Practical Constraints

The tension between the educational benefits of CBCT training and the practical constraints of an already demanding curriculum is a recurring theme. This pattern underscores the need for a balanced approach that maximizes educational outcomes while considering students' workload and capacity.

Evidence:

- Respondent 3: "Students already have a substantial workload to meet graduation requirements. Adding CBCT education would overburden them."

Diverse Pedagogical Approaches

The variation in preferred teaching methods reflects the diverse pedagogical philosophies and experiences of radiology leaders. This pattern suggests that a one-size-

fits-all approach may not be effective, and a hybrid teaching model may be necessary to address the diverse learning needs of students.

Evidence:

- Respondent 4: “Case discussions allow students to engage in critical thinking and analyze each case holistically.”
- Respondent 1: “The ‘Tell-Show-Do’ method involves explaining the concept, demonstrating the procedure, and allowing students to perform the task themselves.”

Resource Allocation and Financial Sustainability

The disagreement over financial incentives and resource allocation highlights the broader challenge of securing adequate funding and support for CBCT education. This pattern emphasizes the need for strategic resource management and sustainable funding models to support the integration of CBCT technology into dental curricula.

Evidence:

- Respondent 6: “Radiology leaders should receive additional bonuses for teaching CBCT, as it requires over 20 hours of extra work per week.”
- Respondent 1: “Securing sufficient funding to hire dedicated CBCT experts and acquire necessary equipment is challenging.”

Standardized Assessment Framework

The differing opinions on how to assess CBCT knowledge and skills indicate a need for a standardized assessment framework. This pattern highlights the importance of

consistent and comprehensive evaluation methods to ensure all students are adequately prepared.

Evidence:

- Respondent 4: “The level of CBCT knowledge and skills is assessed through comprehensive exams, assignments, and hands-on case evaluations.”
- Respondent 1: “The level of CBCT knowledge and skills is assessed through a radiology competency exam administered in the second year.

Summary of Themes and Patterns

These themes and patterns provide a detailed and nuanced understanding of the current state of CBCT education in Midwest dental schools. Addressing these themes through a balanced, hybrid, and strategic approach can help overcome the challenges and enhance the overall quality of CBCT education for dental students. By (a) integrating comprehensive CBCT training into the curriculum, (b) developing a structured syllabus and assessment system, (c) enhancing institutional support and collaboration, (d) providing financial incentives and resources for radiology leaders, (e) implementing effective teaching methods, (f) increasing access to CBCT technology, and (g) promoting research and innovation in CBCT technology, dental schools can ensure that their students are well-equipped with the necessary skills and knowledge to utilize CBCT technology. While these themes provide a broad overview, it is also important to examine the areas where participants distinctly disagreed.

Areas of Distinct Disagreement Among Participants

Despite the common themes, there were notable areas of distinct disagreement among the participants. In analyzing the responses from the radiology leaders in Chapter 4, five areas of distinct disagreement emerged, each revealing underlying complexities and divergent perspectives on the integration of CBCT education into dental curricula. These disagreements are not merely academic; they reflect broader challenges and considerations that must be addressed to advance CBCT education effectively.

The Necessity of CBCT Education for Fourth-Year Dental Students

One of the most pronounced areas of disagreement among participants was the necessity of teaching CBCT to fourth-year dental students. While the majority of respondents emphasized the critical importance of CBCT education for accurate diagnosis and treatment planning, one respondent argued against its necessity, citing the already substantial workload of fourth-year students. This dissenting view highlights a significant tension between the perceived educational benefits of CBCT training and the practical constraints of an already demanding curriculum.

Evidence:

- **Proponents:** Respondents 0, 1, 2, 4, 5, 6, 7, 8, and 9 strongly advocated for the inclusion of CBCT education, emphasizing its role in enhancing diagnostic accuracy and preparing students for clinical practice. For instance, Respondent 0 noted, “Teaching CBCT is necessary for accurately diagnosing bone height, bone width, and angulation of the mandible before implant placement.”
- **Opponent:** Conversely, Respondent 3 contended that adding CBCT education would overburden students, negatively impacting their overall learning

experience. This respondent stated, “Students already have a substantial workload to meet graduation requirements. Adding CBCT education would overburden them.”

This disagreement underscores the need for a balanced approach that considers both the educational value of CBCT training and the practical limitations faced by students.

Effective Teaching Methods for CBCT Education

Another area of distinct disagreement revolves around the most effective teaching methods for CBCT education. While some respondents favored hands-on training and case discussions, others highlighted the “Tell-Show-Do” method as the most effective approach. This divergence reflects differing pedagogical philosophies and experiences with teaching CBCT technology.

Evidence:

- **Hands-On Training Advocates:** Respondents 0, 2, 3, 8, and 9 emphasized the importance of hands-on training. For example, Respondent 0 stated, “Hands-on training is the most effective teaching method for CBCT education.”
- **Case Discussions Proponents:** Respondents 4, 5, and 7 preferred case discussions, with Respondent 4 noting, “Case discussions allow students to engage in critical thinking and analyze each case holistically.”
- **Tell-Show-Do Method Supporters:** Respondent 1 highlighted the “Tell-Show-Do” method, explaining, “This method involves explaining the concept (Tell), demonstrating the procedure (Show), and allowing students to perform the task themselves (Do).”

The variation in preferred teaching methods suggests that a hybrid approach, incorporating elements from each method, may be necessary to address the diverse learning needs of students.

Financial Incentives and Resource Allocation

The third area of disagreement pertains to the financial incentives and resource allocation necessary for effective CBCT education. While some respondents argued for increased financial incentives and resources to support radiology leaders, others were concerned about the feasibility and sustainability of such measures.

Evidence:

- **Pro-Incentive Respondents:** Respondents 6 and 9 advocated for financial incentives, with Respondent 6 stating, “Radiology leaders should receive additional bonuses for teaching CBCT, as it requires over 20 hours of extra work per week.”
- **Skeptical Respondents:** Other respondents expressed concerns about the financial implications. For instance, Respondent 1 noted the challenges of securing sufficient funding to hire dedicated CBCT experts and acquire necessary equipment.

This disagreement highlights the need for a strategic approach to resource allocation that balances the financial realities of institutions with the need to incentivize and support educators effectively.

Assessment of CBCT Knowledge and Skills

A distinct disagreement was seen on how to assess the CBCT knowledge and skills of fourth-year dental students. Some respondents believed in comprehensive, competency-based assessments, while others relied on more traditional examination methods or do not assess CBCT skills at all due to the lack of a dedicated CBCT course.

Evidence:

- **Comprehensive Assessment Advocates:** Respondents 4, 5, and 9 support comprehensive assessments, including exams, assignments, and hands-on case evaluations. Respondent 4 mentioned, "The level of CBCT knowledge and skills is assessed through two exams, two assignments on CBCT technology and its applications, and ten hands-on cases."
- **Traditional Examination Supporters:** Respondents 1 and 2 use traditional exams to assess CBCT knowledge, with Respondent 1 stating, "The level of CBCT knowledge and skills is assessed through a radiology competency exam administered in the second year."
- **Non-Assessors:** Respondents 0, 3, and 7 do not assess CBCT skills due to the absence of CBCT education in their curriculum. Respondent 0 noted, "The institution does not currently teach CBCT to fourth-year dental students, so there is no system in place to assess their level of CBCT knowledge and skills."

This disagreement underscores the need for a standardized assessment framework that ensures all students are evaluated on their CBCT competencies.

Integration of CBCT Education into the Curriculum

Finally, there was a significant disagreement on how to integrate CBCT education into the existing dental curriculum. Some respondents advocate for embedding CBCT training into various courses, while others suggest developing a stand-alone CBCT course or incorporating it into continuing education programs.

Evidence:

- **Integration Advocates:** Respondents 0, 1, and 5 support integrating CBCT training into existing courses. Respondent 0 suggested, "Integrate CBCT training into various courses such as surgery, prosthodontics, and periodontics."
- **Standalone Course Proponents:** Respondents 2 and 7 advocate for a dedicated CBCT course. Respondent 7 stated, "Develop a structured syllabus and an assessment or evaluation system to teach CBCT education to fourth-year dental students."
- **Continuing Education Supporters:** Respondent 3 recommended incorporating CBCT education into continuing education programs, noting, "Interested students can take an optional CBCT educational course through the Continuing Education (CE) department."

This disagreement highlights the need for a flexible and comprehensive approach to curriculum design that accommodates different educational strategies and institutional capabilities. These disagreements highlight discrepancies in the results that warrant further exploration.

Analysis of the Disagreements Within the Overarching Patterns and Themes

The overarching patterns and themes of disagreement among participants provide a deeper understanding of the challenges faced. The disagreements among participants reveal several overarching patterns and themes:

Balancing Educational Value and Practical Constraints

The tension between the educational benefits of CBCT training and the practical constraints of an already demanding curriculum is a recurring theme. This pattern underscores the need for a balanced approach that maximizes educational outcomes while considering students' workload and capacity.

Diverse Pedagogical Approaches

The variation in preferred teaching methods reflects the diverse pedagogical philosophies and experiences of radiology leaders. This pattern suggests that a one-size-fits-all approach may not be effective, and a hybrid teaching model may be necessary to address the diverse learning needs of students.

Resource Allocation and Financial Sustainability

The disagreement over financial incentives and resource allocation highlights the broader challenge of securing adequate funding and support for CBCT education. This pattern emphasizes the need for strategic resource management and sustainable funding models to support the integration of CBCT technology into dental curricula.

Standardized Assessment Framework

The differing opinions on how to assess CBCT knowledge and skills indicate a need for a standardized assessment framework. This pattern highlights the importance of

consistent and comprehensive evaluation methods to ensure all students are adequately prepared.

Flexible Curriculum Design

The varied perspectives on integrating CBCT education into the curriculum suggest a need for a flexible and comprehensive approach to curriculum design. This pattern underscores the importance of accommodating different educational strategies and institutional capabilities to effectively incorporate CBCT training.

These areas of disagreement and the resulting patterns provide valuable insights into the complexities of integrating CBCT education into dental curricula. Addressing these disagreements through a balanced, hybrid, and strategic approach can help overcome the challenges and enhance the overall quality of CBCT education for dental students. Reflecting on these patterns and themes allows us to draw deeper insights from the discrepancies among the results of this study.

Discrepancies Within the Results

The discrepancies among the results underscore the complexity of integrating CBCT education into dental curricula.

Necessity of CBCT Education for Fourth-Year Dental Students

Divergent Responses

While the majority of respondents emphasized the critical importance of CBCT education for accurate diagnosis and treatment planning, one respondent argued against its necessity, citing the already substantial workload of fourth-year students. This dissenting view highlights a significant tension between the perceived educational

benefits of CBCT training and the practical constraints of an already demanding curriculum.

Evidence

- **Proponents:** Respondents 0, 1, 2, 4, 5, 6, 7, 8, and 9 strongly advocated for the inclusion of CBCT education, emphasizing its role in enhancing diagnostic accuracy and preparing students for clinical practice. For instance, Respondent 0 noted, “Teaching CBCT is necessary for accurately diagnosing bone height, bone width, and angulation of the mandible before implant placement.”
- **Opponent:** Conversely, Respondent 3 contended that adding CBCT education would overburden students, negatively impacting their overall learning experience. This respondent stated, “Students already have a substantial workload to meet graduation requirements. Adding CBCT education would overburden them.”

Rationale and Accommodation

The divergence in responses can be attributed to differences in institutional size and administrative structure. Public institutions, which typically have larger student bodies and more complex administrative systems, may find it challenging to integrate additional coursework without overloading students. In contrast, private institutions, with smaller student populations and more streamlined administrative processes, may have greater flexibility to incorporate new educational content.

To accommodate these discrepancies, a tiered approach to CBCT education can be implemented. For larger public institutions, CBCT training could be introduced as an elective course, allowing interested students to opt-in without mandating it for all. This

approach would alleviate concerns about overburdening students while still providing access to essential training for those who seek it. For smaller private institutions, CBCT education can be integrated into the core curriculum, leveraging their ability to make quicker administrative decisions and adapt to new educational needs.

Effective Teaching Methods for CBCT Education

Divergent Responses

Another area of distinct disagreement revolves around the most effective teaching methods for CBCT education. While some respondents favored hands-on training and case discussions, others highlighted the "Tell-Show-Do" method as the most effective approach. This divergence reflects differing pedagogical philosophies and experiences with teaching CBCT technology.

Evidence:

- **Hands-On Training Advocates:** Respondents 0, 2, 3, 8, and 9 emphasized the importance of hands-on training. For example, Respondent 0 stated, "Hands-on training is the most effective teaching method for CBCT education."
- **Case Discussions Proponents:** Respondents 4, 5, and 7 preferred case discussions, with Respondent 4 noting, "Case discussions allow students to engage in critical thinking and analyze each case holistically."
- **Tell-Show-Do Method Supporters:** Respondent 1 highlighted the "Tell-Show-Do" method, explaining, "This method involves explaining the concept (Tell), demonstrating the procedure (Show), and allowing students to perform the task themselves (Do)."

Rationale and Accommodation:

The variation in preferred teaching methods can be linked to the background and training of the respondents. Those with a general medical background may favor the "Tell-Show-Do" method, which is commonly used in medical education to teach procedural skills. In contrast, those with a dental specialist background may prefer hands-on training and case discussions, which are more aligned with the practical and diagnostic nature of dental education.

To accommodate these discrepancies, a hybrid teaching model can be adopted. This model would incorporate elements from each of the preferred methods, ensuring a comprehensive and versatile approach to CBCT education. For instance, the curriculum could begin with the "Tell-Show-Do" method to introduce students to the basic concepts and procedures, followed by hands-on training sessions to allow students to apply their knowledge in practical settings. Case discussions can be integrated throughout the course to foster critical thinking and holistic analysis of clinical scenarios.

Faculty Experience

Divergent Responses

The experience level of faculty members also contributes to the discrepancies in responses. Some faculty members are early in their careers, while others are mid-career or late-career professionals. This variation in experience can influence their perspectives on the necessity and methods of CBCT education.

Evidence

- **Early Career Faculty:** These faculty members may be more open to integrating new technologies like CBCT into the curriculum, as they are often more adaptable and eager to innovate.
- **Mid-Career Faculty:** Faculty in this group may have a balanced view, recognizing the importance of CBCT education while also being mindful of the practical constraints and workload of students.
- **Late Career Faculty:** More experienced faculty members may be resistant to change, preferring traditional teaching methods and being cautious about overloading students with additional coursework.

Rationale and Accommodation:

To address the discrepancies arising from faculty experience, institutions can implement professional development programs that provide training in CBCT technology for faculty at all career stages. This approach ensures that all faculty members, regardless of their experience level, are equipped with the necessary skills and knowledge to teach CBCT effectively. Additionally, fostering a culture of collaboration and mentorship among faculty can help bridge the gap between different experience levels, promoting a more cohesive and supportive teaching environment.

Addressing the discrepancies in participants' responses requires a nuanced understanding of the underlying factors influencing their perspectives. By considering the size and administrative structure of institutions, the background and training of faculty, and the experience levels of faculty members, tailored accommodations can be made to integrate CBCT education effectively. Implementing a tiered approach to course

offerings, adopting a hybrid teaching model, and providing professional development for faculty can ensure that CBCT education meets the diverse needs of students and faculty, ultimately enhancing the quality of dental education and clinical practice. To better understand these discrepancies, we must formulate ten deep reflections on the findings of our research.

Ten Deep Reflections on the Findings

Reflecting on the research journey, several personal and professional insights have emerged.

The Critical Gap in Formal CBCT Training

The absence of formal CBCT training among radiology leaders is a glaring gap that significantly hampers the integration of this technology into pre-doctoral curricula. This deficiency is not merely a logistical oversight but a profound barrier to advancing dental education. The data reveals that many radiology leaders, having been trained before the widespread adoption of CBCT in the 1990s, lack the necessary expertise to teach this technology effectively. This gap underscores the urgent need for structured training programs that can equip educators with the skills required to impart CBCT knowledge to their students. Without addressing this foundational issue, any efforts to integrate CBCT into dental education will be fundamentally flawed.

The Overwhelming Burden on Radiology Leaders

Radiology leaders are often caught in a relentless cycle of clinical responsibilities and teaching commitments, which severely limits their capacity to innovate and integrate new educational content. The COVID-19 pandemic has only exacerbated this issue,

placing additional demands on their time and resources. The data highlights that these leaders are frequently overburdened, leaving little room for the development and implementation of new curricula, such as CBCT education. This reflection calls for a reevaluation of workload distribution and the provision of additional support to enable radiology leaders to focus on educational advancements.

Institutional Support and Recognition

The lack of institutional support and recognition for the significance of CBCT education is a critical obstacle. School administrators, curriculum committees, and faculty assemblies have not prioritized CBCT education, which hinders its integration into the curriculum. The data suggests that without institutional backing, efforts to incorporate CBCT education will remain fragmented and ineffective. This reflection emphasizes the need for a concerted effort from all levels of the institution to recognize and support the integration of CBCT technology into dental education.

The Necessity of CBCT Education for Accurate Diagnosis

Teaching CBCT to fourth-year dental students is not just beneficial but essential. The data clearly shows that CBCT technology is crucial for accurately diagnosing bone height, bone width, and angulation of the mandible before implant placement, as well as for identifying the number and shape of canals before endodontic procedures. This reflection underscores the importance of incorporating CBCT education into the curriculum to prepare students for the clinical challenges they will face in their professional practice.

Key Components and Skills for CBCT Education

The essential components for CBCT education include a comprehensive understanding of CBCT technology, the ability to download and open CBCT files, trace the mandibular canal, and evaluate sinuses before implant surgery. The data highlights the need for students to develop skills in assessing endodontic procedures, periodontal bone loss, TMJ diseases, and basic pathology detection. This reflection calls for a structured syllabus that covers these key components and ensures that students are well-prepared to utilize CBCT technology in their clinical practice.

Effective Teaching Methods for CBCT Education

The most effective teaching methods for CBCT education, as highlighted by the data, include hands-on training, case discussions, and the "Tell-Show-Do" method. These methods enhance students' learning experiences by allowing them to apply theoretical knowledge in practical settings and engage in critical thinking. This reflection emphasizes the importance of adopting these teaching methods to ensure that students gain a deep and practical understanding of CBCT technology.

Financial Constraints and Resource Allocation

Financial constraints and the high cost of CBCT machines and software licenses pose significant challenges to the integration of CBCT education. The data reveals that insufficient budgets and the lack of financial incentives for radiology leaders are major barriers. This reflection calls for a strategic allocation of resources and the provision of financial incentives to support the integration of CBCT technology into dental education. Without addressing these financial barriers, the adoption of CBCT education will remain limited.

The Transformative Impact of CBCT Technology

Integrating CBCT technology into clinical practice has been transformative for radiology leaders, significantly improving patient care by enhancing diagnostic precision and treatment planning. The data shows that CBCT technology has increased clinical efficiency, reduced treatment time and resources, and led to higher patient satisfaction and trust. This reflection highlights the profound impact of CBCT technology on clinical practice and underscores the importance of integrating it into dental education to prepare students for the future of dental care.

The Role of Interdepartmental Collaboration

The lack of cooperation and collaboration among departments is a significant barrier to the integration of CBCT education. The data suggests that fostering a collaborative environment is essential for the successful implementation of CBCT programs. This reflection emphasizes the need for interdepartmental collaboration to ensure a cohesive approach to CBCT training and to leverage the expertise and resources of different departments.

Long-Term Benefits of CBCT Education

The long-term benefits of CBCT education on clinical practice, including improved patient outcomes and reduced legal risks, are significant. The data indicates that comprehensive CBCT training can lead to better diagnostic accuracy, clinical efficiency, and patient care. This reflection underscores the importance of investing in CBCT education to ensure that dental graduates are well-equipped to meet the demands of modern dental practice and to provide the highest standard of care to their patients.

These reflections highlight the critical areas that need attention to improve CBCT education.

Evidence of Struggling to Understand Data

Taking a broader view, the evidence of struggling to understand data reveals additional layers of complexity. The struggle to understand and integrate CBCT data into dental education is primarily due to several interconnected factors:

Lack of Formal Training

Many radiology leaders lack formal training in CBCT technology, which hinders their ability to teach it effectively.

Overburdened Leaders:

Radiology leaders are often overwhelmed with clinical and teaching responsibilities, leaving little time for curriculum development.

Institutional Support:

There is insufficient support from school administrators and curriculum committees to prioritize CBCT education.

Financial Constraints:

The high cost of CBCT machines and software licenses, coupled with limited budgets, restricts access to necessary resources.

Interdepartmental Issues:

Lack of collaboration among departments further complicates the integration of CBCT education.

These factors collectively contribute to the struggle in understanding and implementing CBCT data within dental curricula. Addressing these issues requires a multifaceted approach, including formal training programs, financial incentives, institutional support, and enhanced collaboration.

Exploring the Advantages and Disadvantages of CBCT Training Programs

Comprehensive CBCT Training Programs

Advantages:

Enhanced Diagnostic Accuracy: Comprehensive training improves students' ability to make accurate diagnoses, leading to better patient outcomes.

Clinical Efficiency: Well-trained students can utilize CBCT technology efficiently, reducing treatment time and resources.

Legal Risk Management: Proper training minimizes diagnostic errors, reducing the likelihood of lawsuits.

Disadvantages:

High Costs: Developing and maintaining comprehensive training programs can be expensive.

Resource Allocation: Significant resources are required, which may strain institutional budgets.

Time-Consuming: Implementing comprehensive training programs can be time-consuming for both educators and students.

Institutional Support and Collaboration

Advantages:

Integrated Curriculum: Institutional support ensures CBCT education is seamlessly integrated into the dental curriculum.

Resource Sharing: Collaboration among departments allows for efficient use of resources and expertise.

Enhanced Learning Environment: A supportive institutional environment fosters a positive learning experience for students.

Disadvantages:

Administrative Challenges: Gaining institutional support and fostering collaboration can be challenging and time-consuming.

Potential Resistance: Resistance from faculty or departments may hinder collaborative efforts.

Resource Dependency: Successful collaboration depends on the availability of adequate resources and support.

Financial Incentives and Resources

Advantages:

Motivated Educators: Financial incentives can motivate radiology leaders to invest time and effort in teaching CBCT.

Improved Training Quality: Adequate resources ensure high-quality training programs and access to the latest technology.

Equitable Access: Financial support can provide equitable access to CBCT technology for all students.

Disadvantages:

Budget Constraints: Providing financial incentives and resources may strain institutional budgets.

Sustainability Issues: Ensuring long-term financial support for CBCT education can be challenging.

Potential Inequities: Disparities in resource allocation may arise, leading to unequal access to CBCT training.

These big picture evaluations provide a comprehensive overview of the advantages and disadvantages associated with different approaches to integrating CBCT education into dental curricula. Addressing these factors can help overcome the challenges and enhance the overall quality of dental education. These explorations of the advantages and disadvantages provide a comprehensive understanding of the multifaceted nature of CBCT education.

Recommendations

Looking ahead, further research is needed to explore additional aspects of CBCT integration. In light of the critical need to enhance CBCT education for fourth-year dental students, these recommendations aim to address the multifaceted challenges identified through comprehensive research and respondent feedback. By (a) integrating comprehensive CBCT training into the curriculum, (b) developing a structured syllabus and assessment system, (c) enhancing institutional support and collaboration, (d) providing financial incentives and resources for radiology leaders, (e) implementing effective teaching methods, (f) increasing access to CBCT technology, (g) incorporating CBCT education into CE programs, and (h) promoting research and innovation in CBCT

technology, these recommendations would ensure that dental students are well-equipped with the necessary skills and knowledge to utilize CBCT technology effectively in their future practices.

Integrate Comprehensive CBCT Training into the Curriculum

To address the lack of formal training among radiology leaders and ensure that students are well-prepared for clinical practice, it is essential to integrate comprehensive CBCT training into the dental curriculum. This training should encompass theoretical foundations, practical applications, and hands-on experience with CBCT machines. Embedding CBCT education into various courses such as surgery, prosthodontics, and periodontics will provide students with a holistic understanding of its applications across different dental specialties.

Develop a Structured Syllabus and Assessment System

A structured syllabus specifically designed for CBCT education should be developed to provide a clear framework for both instructors and students. This syllabus should outline the key components and skills essential for CBCT education, including the ability to download and open CBCT files, trace the mandibular canal, and evaluate sinuses before implant surgery. Additionally, an assessment system should be implemented to evaluate student proficiency in CBCT technology through exams, assignments, and hands-on case evaluations.

Enhance Institutional Support and Collaboration

Institutional support is crucial for the successful integration of CBCT education. School administrators, curriculum committees, and faculty assemblies should recognize

the significance of CBCT education and prioritize its inclusion in the curriculum. Collaboration among departments is also essential to ensure a cohesive approach to CBCT training. By fostering a supportive environment and encouraging interdepartmental cooperation, institutions can overcome the challenges associated with integrating CBCT education.

Provide Financial Incentives and Resources for Radiology Leaders

To address the issue of overburdened radiology leaders and the lack of formal training, financial incentives and additional resources should be provided. Radiology leaders should receive bonuses for their extra efforts in teaching CBCT technology, and funding should be allocated to hire dedicated CBCT experts. This will not only enhance the quality of CBCT education but also alleviate the workload of radiology leaders, allowing them to focus on developing and delivering effective CBCT training.

Implement Effective Teaching Methods

The most effective teaching methods for CBCT education include hands-on training, case discussions, and the "Tell-Show-Do" method. Hands-on training allows students to apply theoretical knowledge in practical settings, enhancing their learning experience. Case discussions enable students to engage in critical thinking and integrate knowledge from both dental and medical sciences. The "Tell-Show-Do" method, which involves explaining the concept, demonstrating the procedure, and allowing students to perform the task themselves, is highly effective in enhancing students' planning and accuracy in clinical practice. These methods should be systematically incorporated into the CBCT curriculum to ensure comprehensive and effective education.

Increase Access to CBCT Technology

To ensure equitable access to CBCT technology for all students, institutions should invest in acquiring additional CBCT machines and software licenses. This will allow fourth-year dental students to practice and complete their clinical cases more flexibly. Providing sufficient resources and equipment is essential for hands-on training and for students to gain practical experience with CBCT technology.

Incorporate CBCT Education into Continuing Education Programs

For students who may not receive adequate CBCT training during their pre-doctoral education, institutions should offer optional CBCT educational courses through CE programs. These courses can provide additional training and certification in CBCT technology, ensuring that all graduates have the opportunity to become proficient in this essential diagnostic tool.

Promote Research and Innovation in CBCT Technology

Encouraging research and innovation in CBCT technology within dental schools can lead to advancements in diagnostic imaging and treatment planning. Institutions should support faculty and students in conducting research projects related to CBCT, fostering an environment of continuous learning and improvement. By staying at the forefront of technological advancements, dental schools can ensure that their CBCT education programs remain relevant and cutting-edge.

By implementing these eight recommendations, radiology leaders can significantly improve CBCT education for fourth-year dental students, ensuring they are well-equipped with the necessary skills and knowledge to utilize CBCT technology effectively in their future practices.

The integration of CBCT in dental education is a multifaceted challenge that requires addressing several critical barriers. This study provided significant insights into the current state of CBCT education in Midwest dental schools, identifying the barriers to its integration, the necessity of CBCT training for fourth-year dental students, and the transformative impact of CBCT on clinical practice. The research study demonstrated that a lack of formal training among radiology leaders, insufficient institutional support, and financial constraints are major obstacles to effective CBCT education.

Recommendations for Future Research

This exploration of CBCT education for fourth-year dental students revealed several critical themes and subthemes underscoring the need for targeted future research. These themes include (a) the necessity of comprehensive CBCT training programs, (b) the pivotal role of institutional support and collaboration, (c) the financial and resource implications of integrating CBCT education, (d) the effectiveness of various teaching methods, and (e) the long-term impact of CBCT education on clinical practice. Each of these themes highlights specific areas where further investigation can provide valuable insights and practical solutions to enhance CBCT education. The following recommendations for future research are designed to address these themes, offering a roadmap for advancing the field and ensuring that dental students are well-equipped with the skills and knowledge necessary to utilize CBCT technology effectively in their professional practice.

Examine the Impact of Comprehensive CBCT Training Programs

Future research should investigate the effectiveness of comprehensive CBCT training programs that include both theoretical and practical components. Studies should

assess how these programs influence student diagnostic accuracy, clinical decision-making, and overall competence in using CBCT technology. Longitudinal studies could provide insights into the retention of skills and knowledge over time.

Evaluate the Role of Institutional Support and Collaboration

Research should explore the impact of institutional support and interdepartmental collaboration on the successful integration of CBCT education. This includes examining the effects of administrative policies, funding allocation, and faculty cooperation on the implementation and sustainability of CBCT programs. Identifying best practices for fostering a supportive and collaborative environment can help other institutions enhance their CBCT education efforts.

Assess the Financial and Resource Implications of CBCT Education

Future studies should conduct cost-benefit analyses to determine the economic feasibility of integrating CBCT education into dental curricula. This includes evaluating the costs associated with acquiring CBCT machines, software licenses, and training faculty, as well as the potential financial benefits, such as improved clinical outcomes and increased practice revenue. Research could also explore funding models and resource allocation strategies to support equitable access to CBCT technology for students.

Investigate the Effectiveness of Different Teaching Methods

Comparative studies are needed to evaluate the effectiveness of various teaching methods for CBCT education, such as hands-on training, case discussions, and the "Tell-Show-Do" method. Research should focus on measuring student engagement, knowledge retention, and practical skills acquisition. Additionally, the impact of these teaching

methods on student clinical performance and diagnostic accuracy should be assessed to identify the most effective approaches.

Explore the Long-Term Impact of CBCT Education on Clinical Practice

Longitudinal research should examine the long-term impact of CBCT education on clinical practice. This includes tracking the career trajectories of dental graduates who received CBCT training and assessing their proficiency in using CBCT technology in their professional practice. Studies should also investigate the impact of CBCT education on patient outcomes, clinical efficiency, and overall quality of care provided by these practitioners. Understanding these long-term effects can help refine CBCT education programs to better prepare students for their future careers.

Researcher Reflections

Reflecting on the research journey, several personal and professional insights have emerged. The integration of CBCT technology in dental and medical practices is not only a technological advancement but also a moral and legal imperative. Radiology leaders, dentists, physicians, and surgeons bear the responsibility to utilize CBCT technology judiciously to enhance patient care. However, a concern is that some radiology leaders withhold CBCT education from students to monopolize the market for financial gain through private practice. This practice undermines the educational mission and compromises the quality of patient care. Conversely, there are instances where surgeons neglect to use available CBCT technology in their clinical practice, leading to preventable medical errors. A notable example is the case of a Macomb County man who was awarded $2.75 million in a medical malpractice lawsuit after suffering a massive hemorrhage caused by an oral surgeon, resulting in injury to his lingual artery and

significant blood loss (Hall, 2024). This tragic outcome could have been avoided with the use of CBCT technology and proper consultation with a radiology leader. The ethical, moral, and legal obligations of medical professionals demand that they avoid unnecessary procedures aimed at generating profit, as such actions are unequivocally unethical and illegal. Furthermore, medical insurance companies should recognize the value of CBCT technology by providing coverage codes for these procedures. The lack of insurance coverage deters patients from opting for CBCT, despite its critical role in accurate diagnosis and treatment planning. Addressing these issues is essential to ensure that CBCT technology is used to its full potential, ultimately improving patient outcomes and upholding the integrity of the medical profession. In conclusion, these reflections underscore the importance of continued efforts to integrate CBCT education into dental curricula.

Conclusion

In conclusion, this study provided significant insights into the current state of CBCT education in Midwest dental schools, addressing the research questions by identifying the barriers to its integration, the necessity of CBCT training for fourth-year dental students, and the transformative impact of CBCT on clinical practice. The research demonstrated that a lack of formal training among radiology leaders, insufficient institutional support, and financial constraints are major obstacles to effective CBCT education. The contributions of the study are substantial, highlighting the critical role of CBCT in enhancing diagnostic accuracy, clinical efficiency, and legal risk management, thereby underscoring its importance in dental education. However, limitations such as the small sample size and potential biases among respondents must be acknowledged. Future

research should focus on evaluating comprehensive CBCT training programs, exploring the role of institutional support, assessing the financial implications, and investigating the long-term impact of CBCT education on clinical practice to further refine and enhance CBCT education for dental students. By addressing these areas, future studies can provide valuable insights and practical solutions to optimize CBCT education, ensuring that dental students are well-equipped with the necessary skills and knowledge to utilize this advanced diagnostic tool effectively in their professional practice. By acknowledging the challenges and implementing the proposed recommendations, we can significantly enhance the quality of dental education and clinical practice.

APPENDICES

APPENDIX A

INTERVIEW QUESTIONS

1. Could you explain your thoughts on why many radiology leaders have not incorporated CBCT education into their curriculum?
2. Why do you believe teaching CBCT to fourth-year dental students is necessary? Why or why not?
3. How do you consider to be the key components and specific skills that are essential for fourth-year dental students to acquire through CBCT education?
4. Please share the most effective teaching methods for CBCT education.
5. How do you currently assess the level of CBCT knowledge and skills among fourth-year dental students?
6. Explain improvements or changes would you suggest for enhancing CBCT education for fourth-year dental students.
7. Please explain the main challenges you face in teaching CBCT, and how you address issues related to the cost and accessibility of the technology.
8. Please share your personal views on integrating CBCT into your own practice and how it has impacted your clinical work.

APPENDIX B

APPLICATION FOR APPROVAL OF HUMAN SUBJECTS RESEARCH

Office of Research and Creative Scholarship
Institutional Review Board
(269) 471-6361 Fax: (269) 471-6246 E-mail: irb@andrews.edu
Andrews University, Berrien Springs, MI 49104-0355

APPLICATION FOR APPROVAL OF HUMAN SUBJECTS RESEARCH

Please complete this application as thoroughly as possible. Your application will be reviewed by a committee of Andrews University IRB, and if approved it will be for one year. Beyond the one year you will be required to submit a continuation request. It is the IRB's responsibility to assign the level of review: Exempt, Expedited or Full. It is your responsibility to accurately complete the form and provide the required documents. Should your application fall into the exempt status, you should expect a response from the IRB office within 2 weeks; Expedited within 2 weeks and a Full review 4-6 weeks.

http://www.andrews.edu/services/research/research_compliance/institutional_review/
Please complete the following application:

<table>
<tr><td colspan="3">1. Research Project</td></tr>
<tr><td colspan="3">a) Title: CBCT Perception of Radiology Leaders in the Midwest Dental Schools – A Qualitative Study</td></tr>
<tr><td colspan="3">Will the research be conducted on the AU campus? _X_ Yes ___ No
If no, please indicate the location(s) of the study and attach an institutional consent letter that references the researcher's study.
b) What is the source of funding (please check all that apply)</td></tr>
<tr><td colspan="2">__X_Unfunded</td><td></td></tr>
<tr><td>___Internal Funding</td><td>Source:</td><td rowspan="3"></td></tr>
<tr><td>___External Funding</td><td>Sponsor/Source:</td></tr>
<tr><td>Grant title:</td><td>Award # / Charging String:</td></tr>
<tr><td colspan="3">If you do not know the funding/grant information, please obtain it from your department</td></tr>
<tr><td colspan="3">2. Principal Investigator (PI)</td></tr>
<tr><td colspan="3">First Name: Last Name: Telephone: E-mail:
Tenzin Dadul (612) 707-5104 dadul@andrews.edu</td></tr>
<tr><td colspan="3">_X__ Yes I am a student. If so, please provide information about your faculty advisor below.</td></tr>
<tr><td colspan="3">First Name: Last Name: Telephone: E-mail:</td></tr>
</table>

Jay Brand (269) 471-3784 brand@andrews.edu
Advisor's signature:
Department: Leadership: Program: Doctor of Philosophy in Leadership
3. Co-investigators (Please list their names and contact information below)
First Name: Last Name: Telephone: E-mail: Jay Brand (269) 471-3784 brand@andrews.edu
First Name: Last Name: Telephone: E-mail: Sharon Aka (269) 697-9515 akas@andrews.edu
First Name: Last Name: Telephone: E-mail: Sung Kwon (269) 471-3994 kwons@andrews.edu
4. Cooperating Institutions
Is this research being done in cooperation with any institutions, individuals or organizations not affiliated with AU? ___ Yes __X_ No If yes, please provide the names and contact information of authorized officials below. Name of Organization: Address: First Name: Last Name: Telephone: E-mail: First Name: Last Name:Telephone: E-mail:
Have you received IRB approval from another institution for this study? ___ Yes _X_ No If yes, please attach a copy of the IRB approval.
5. Participant Recruitment
Describe how participant recruitment will be performed. Include how and by whom potential participants are introduced to the study (please check all below that apply)
___ AU directory ___ Postings, Flyers ___ Radio, TV
_X__ E-mail solicitation. Indicate how the email addresses are obtained: We will search the Radiology leaders email addresses for available to public online at Midwest universities and private practices.
___ Web-based solicitation. Specify sites:
___ Participant Pool. Specify what pool: We will select ten radiology leaders in the Midwest states.
___ Other, please specify:
Please attach any recruiting materials you plan to use and the text of e-mail or web-based solicitations you will use. We will search ten radiology leaders in the Midwest states in the private practice or hospital or university websites and request them to participate in a voluntary and anonymous research. Their responses will be de-identified by assigning a random number to each participant. These radiology leaders are independent radiologists working in their private practices. We will send this email to the potential participants. The text of the email will be: "_____"
6. Participant Compensation and Costs

Are participants to be compensated for the study? Yes ___ No _X__ If yes, what is the amount, type and source of funds?		
Amount:	Source:	Type:
Will participants who are students be offered class credit? ___ Yes _X__ No ___ NA		
Are other inducements planned to recruit participants? ___ Yes _X_ No If yes, please describe.		
Are there any costs to participants? ___ Yes _X__ No If yes, please explain.		
7. Confidentiality and Data Security		
Will personal identifiers be collected? ___ Yes _X_No	Will identifiers be translated to a code? _X_Yes ___No	
Will recordings be made (audio, video)? ___ Yes _X__ No If yes, please describe.		
Who will have access to data (survey, questionnaires, recordings, interview records, etc.)? Please list below. Tenzin Dadul will have the list of anonymized and deidentified interview responses/data. We will assign random numbers to all participants to keep the data anonymized and de-identified in an encrypted computer at the Andrews University School of Leadership.		
8. Conflict of Interest		
Do you (or any individual who is associated with or responsible for the design, the conduct of or the reporting of this research) have an economic or financial interest in, or act as an officer or director for, any outside entity whose interests could reasonably appear to be affected by this research project: ___ Yes _X__ No If yes, please provide detailed information to permit the IRB to determine if such involvement should be disclosed to potential research subjects.		
9. Results		
To whom will you present results (highlight all that apply) __ Class _X_ Conference __X_ Published Article ___ Other If other, please specify:		
10. Description of Research Subjects		
If human subjects are involved, please highlight all that apply: ___ Minors (under 18 years) ___ Prison inmates ___ Mentally impaired ___ Physically disabled ___ Institutionalized residents ___ Anyone unable to make informed decisions about participation ___ Vulnerable or at-risk groups, e.g., poverty, pregnant women, substance abuse population		
11. Risks		
Are there any potential damage or adverse consequences to researcher, participants, or environment? These include physical, psychological, social, or spiritual risks whether as part of the protocol or a remote possibility. Please highlight all that apply (Type of risk): There is no potential damage or adverse consequences to researcher, participants, or environment. There is no physical, psychological, social, or spiritual risks whether as part of the protocol or a remote possibility. ___ Physical harm ___ Psychological harm ___ Social harm ___ Spiritual harm		

12. Content Sensitivity
Does your research address culturally or morally sensitive issues? ___ Yes _X_ No If yes, please describe:
13. Please provide (type in or copy - paste or attach) the following documentation in the boxes below:

Protocol:
Please see in the attachment. Thank you!

Survey instrument or interview protocol:

1. Could you explain your thoughts on why many radiology leaders have not incorporated CBCT education into their curriculum?
2. Why do you believe teaching CBCT to fourth-year dental students is necessary? Why or why not?
3. How do you consider to be the key components and specific skills that are essential for fourth-year dental students to acquire through CBCT education?
4. Please share the most effective teaching methods for CBCT education.
5. How do you currently assess the level of CBCT knowledge and skills among fourth-year dental students?
6. Explain improvements or changes would you suggest for enhancing CBCT education for fourth-year dental students.
7. Please explain the main challenges you face in teaching CBCT, and how do you address issues related to the cost and accessibility of the technology.
8. Please share your personal views on integrating CBCT into your own practice and how it has impacted your clinical work.

Institutional approval letter (if off AU campus): N/A

Consent form (for interviews and focus groups):
Please see in the attachment

Participants recruitment documents:
Please see in the attachment

National Institute of Health certificate of training completion
Please see in the attachment

Principal Investigator's Assurance Statement for Using Human Subjects in Research

__**X**__ I certify that the information provided in this IRB application is complete and accurate.

__X__ I certify that co-investigators have approved application for IRB submission.

____X__ I understand that as Principal Investigator, I have ultimate responsibility for the conduct of IRB approved studies, the ethical performance of protocols, the protection of the rights and welfare of human subjects, and strict adherence to the study's protocol and any stipulation imposed by Andrews University Institutional Review Board.

___X___ I will submit modifications and / or changes to the IRB as necessary prior to implementation.

___X___ I agree to comply with all Andrews University's policies and procedures, as well as with all applicable federal, state, and local laws, regarding the protection of human participants in research.

____X__ My advisor has reviewed and approved my proposal.

INFORMED CONSENT FORM

(Attachment to IRB Application)

Research Title: CBCT Perception of Radiology Leaders in the Midwest Dental Schools - A Qualitative Study

Please read this consent document carefully before you decide to participate in this study.

Principal Investigator: *Tenzin Dadul*

Research Advisor: *Dr. Jay Brand*

Statements about the Research:

This research study is part of my dissertation project, in partial fulfillment for my degree in Ph.D. in Leadership, at Andrews University, Berrien Springs, Michigan. Your participation in this study is greatly appreciated.

Purpose of Study: The purpose of this research is to explore the perceptions of radiology leaders in the Midwest regarding the Cone Beam Computed Tomography (CBCT) and its implication for clinical practice.

Procedures: Participants will be requested to answer ten interview questions on CBCT perception for radiology leaders in the Midwest. It will take 10 minutes to answer these questions. We will not ask any personal or political or sensitive questions.

Duration of participation in study: It will take 10 minutes to answer ten interview questions.

Risks and Benefits: There is not any reasonably foreseeable risks or discomfort and benefit for participating in this research.

- Emotional risks (e.g., feelings of sadness or anxiety)
- Social or economic risks (e.g., loss of confidentiality; effects to financial standing, employability, or insurability)
- Legal risks (e.g., possibility of discovering activities that may require reporting to authorities, possibility of being arrested)
- Physical risks (e.g., nausea, muscle aches, rashes, infection, discomforts, etc.)If there are no known risks, state: I/We do not anticipate any risks from participating in this research.

For research which may involve more than minimal risk of injury the subject should be informed of the following statement which must appear in the consent form: (to be modified for off-campus research*)*.

> In the unlikely event of injury resulting from this research, Andrews University is not able to offer financial compensation nor to absorb the costs of medical treatment. However, assistance will be provided to research subjects in obtaining emergency treatment and professional services that are available to the community generally at nearby facilities. My signature below acknowledges my consent to voluntarily participate in this research project. Such participation does not release the investigator(s), sponsor(s) or granting agency/agencies from their professional and ethical responsibility to me.

Voluntary Participation: Participation in this study is completely voluntary, refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may discontinue participation at any time without penalty or loss of benefits to which you may otherwise be entitled.

Privacy/Confidentiality/Data Security

Briefly explain how you will protect the participant's privacy and/or confidentiality.

We will de-identify personal information, such as names and email addresses, by assigning a random number to each participant's responses. Consent forms will be securely stored on an encrypted computer at the Andrews University School of Leadership. Interview data will be kept on an encrypted computer belonging to Tenzin Dadul, the primary investigator. Research data will be stored on an encrypted computer at the Andrews University School of Leadership for a period of three years. During this time, only Tenzin Dadul will have access to identifying information. The data will be kept secure in an encrypted environment and will be permanently destroyed at the end of the three-year period.

For research that involves Internet-based surveys, include the following *statement when using Qualtrics:*

We anticipate that your participation in this survey presents no greater risk than everyday use of the internet.

Confidentiality: Your identity will be kept confidential to the extent of the law. There will be nothing linking you to the study. None of your identifiers, if any, will be used in any report or publication.

Whom to Contact: If you have any questions about your rights as a subject/participant in this research, contact my advisor Dr. Jay Brand (name) (269) 471-3784 (telephone), brand@andrews.edu (email); or researcher Tenzin Dadul (name), (612) 707-5104 (telephone), dadul@andrews.edu (email). You can also contact the IRB Office at irb@andrews.edu or at (269) 471-6361.

Statement of Consent

Signed consent is not necessary in all situations, and will not be possible if your study is anonymous. If you think that signatures will jeopardize your research or not possible or practical, please describe, in your IRB application how you plan to document consent. For an online experiment asking participants to click on an "I approve" box should be sufficient.

I have read the above information, and have received answers to any questions I asked. I Consent to take part in the study.

Your Signature _____Date _____
Your Name (printed) _ _____Date _____
Signature of person obtaining consent: _____Date ____
Printed name of person obtaining consent: _____Date __

Andrews University

Online Informed Consent Form and Participation Letter

You are being invited to participate in a research study titled ***"CBCT Perception of Radiology Leaders in the Midwest Dental Schools - A Qualitative Study"***. This study is being done by ***Tenzin Dadul, Dr. Jay Brand, Dr. Sharon Aka, Dr. Sung Kwon*** from Andrews University. You were selected to participate in this study because ***you train pre-doctoral students in CBCT & Radiology***. The purpose of this research study is ***to explore the radiology leaders' perception on CBCT technology and its implication for clinical practical in the Midwest.*** If you agree to take part in this study, you will be asked to complete an online questionnaire. This questionnaire will ask about ***CBCT Perception of Radiology Leaders in the Midwest Dental Schools - A Qualitative Study*** and it will take you approximately ***10*** minutes to complete.

You may not directly benefit from this research, however, we hope that your participation in the study may ***enhance CBCT education within the dental curriculum at Midwest dental schools, thereby improving diagnostic accuracy and clinical efficiency in the radiology clinics***.

We believe there are no known risks associated with this research study, however, as with any online related activity, the risk of a breach of confidentiality is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by ***anonymizing and de-identifying your personal information through the assignment of a random number to your responses. Your responses will be de-identified on the Andrews University's encrypted computer. Only Dadul will have access to your responses and the data will be permanently destroyed in 3 years.*** Your participation in this study is completely voluntary and you can withdraw at any time. You are free to skip any question that you choose.

If Applicable **(N/A)**- For surveys covering sensitive subject matter, include steps you will use to minimize any potential risks or minimizing risks. Please include the following statement in the informed consent AND include a debriefing form at the end of the survey: "As researchers we are not qualified to provide counseling services and we will not be following up with you after this study. If you feel upset after completing the study, or find that some questions or aspects of the study triggered distress, talking with a

qualified clinician may help. If you feel you would like assistance please contact ***insert the treatment and professional services that are available to the community generally at nearby facilities.***

My signature below acknowledges my consent to voluntarily participate in this research project. Such participation does not release the investigator(s), sponsor(s) or granting agency(ies) from their professional and ethical responsibility to me. In the case of an emergency please call 911."

If you have questions about this project or if you have a research-related problem, you may contact the researcher's advisor ***Dr. Jay Brand, and (269-471-3784)***. Or the researcher(s), ***Tenzin Dadul and phone number (612-707-5104***. If you have any questions concerning your welfare and rights as a research subject, you may contact the Andrews University IRB Office at (269) 471-6361 or irb@andrews.edu

By clicking "I agree" below you are indicating that you are at least 18 years old, have read and understood this consent form and agree to participate in this research study. Please print a copy of this page for your records.

I Agree I Do Not Agree

APPENDIX C

INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

Andrews University
Office of Research & Creative Scholarship

September 19, 2024

Tenzin Dadul
Tel. 612-707-5104
Email: dadul@andrews.edu

RE: APPLICATION FOR APPROVAL OF RESEARCH INVOLVING HUMAN SUBJECTS
IRB Protocol #:24-094 **Application Type:** Original **Dept.:** Leadership
Review Category: Exempt **Action Taken**: Approved **Advisor:** Jay Brand
Title: CBCT perception of radiology leaders in the Midwest dental schools- A qualitative study.

Your IRB application for approval of research involving human subjects entitled*: "CBCT perception of radiology leaders in the Midwest dental schools- A qualitative study"* IRB protocol # 24-094 has been evaluated and determined Exempt from IRB review under regulation CFR 46.104 (2)(i): Research that includes interview procedures and in which information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subject. You may now proceed with your research.

Please note that any future changes made to the study design or informed consent form require prior approval from the IRB before such changes can be implemented. Incase you need to make changes please use the attached report form.

While there appears to be no more than minimum risks with your study, should an incidence occur that results in a research-related adverse reaction or physical injury, this must be reported immediately in writing to the IRB. Any research-related physical injury must also be reported immediately to the University Physician, Dr. Katherine, by calling (269) 473-2222.

We ask that you reference the protocol number in any future correspondence regarding this study for easy retrieval of information.

Best wishes in your research.

Sincerely,

Mordekai Ongo, PhD.
Research Integrity and Compliance Officer

Institutional Review Board – 8488 E Campus Circle Dr Room 234 - Berrien Springs, MI 49104-0355
Tel: (269) 471-6361 E-mail: irb@andrews.edu

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