AUCTORES
Globalize your Research

Journal of Clinical Research and Reports

Abdulwahab Ismail Al-Kholani *

Open Access

Research Article

The Efficiency of CBCT X-Ray in Detecting Caries Under Cemented and Uncemented Dental Fixed Prosthesis

Abdulrahman Ebrahim Al-Mansor [1], Ibrahim Zaid Al-Shami [2], Abdulwahab Ismail Al-kholani[3]*

[1]Master Degree in Restorative and Esthetic Dentistry, Faculty of Dentistry, Sana'a University, Sana'a, Yemen.

[2]Professor in Restorative and Esthetic Dentistry, Faculty of Dentistry, Sana'a University, Yemen.

[3]Dean Faculty of Dentistry on 21 September University, Head of Restorative and Esthetic Dentistry Department, Dental Implant Consultant, Yemen

***Corresponding Author:** Abdulwahab Ismail Al-Kholani, Dean Faculty of Dentistry on 21 September University, Sana'a Yemen.

Received date: February 03, 2025; **Accepted date:** February 10, 2025; **Published date:** March 03, 2025

Citation: Abdulrahman Ebrahim Al-Mansor, Ibrahim Zaid Al-Shami, Abdulwahab Ismail Al-kholani, (2025), The Efficiency of CBCT X-Ray in Detecting Caries Under Cemented and Uncemented Dental Fixed Prosthesis, *J Clinical Research and Reports,* 19(1); **DOI:**10.31579/2690-1919/497

Abstract

Aim: This study aims to assess the efficiency of cone-beam computed tomography (CBCT) in detecting secondary caries under various types of fixed prostheses, including zirconia, e-max, porcelain-fused-to-metal, and acrylic CAD/CAM, and to evaluate whether dental cement acts as a barrier to caries detection.

Materials and Methods: An in vitro experimental study was conducted using 116 caries-free human premolar teeth, divided into four main groups based on the type of fixed prosthesis. Each group was further subdivided according to caries depth (0-1 mm, 1-2 mm, 2-3 mm). A pilot study was performed to establish the methodology, followed by CBCT imaging before and after cementation with glass ionomer cement. The images were analyzed using Ez3D-I software, and data were statistically evaluated using SPSS software.

Results: Significant differences in caries detection rates were observed before and after cementation for zirconia (100% to 58.33%, $p = 0.002$) and porcelain-fused-to-metal crowns (100% to 66.67%, $p = 0.005$). No significant differences were found for acrylic CAD/CAM and empress crowns. The study demonstrated excellent intraobserver reliability for caries and composite measurements.

Conclusion: CBCT is an effective tool for detecting secondary caries under cemented and uncemented dental fixed prostheses, particularly for zirconia and porcelain-fused-to-metal crowns. Early detection of secondary caries is crucial for preserving tooth structure and improving treatment outcomes. Given its non-invasive nature and superior imaging capabilities, CBCT should be integrated into clinical practice for enhanced diagnostic accuracy.

Keywords: cone-beam computed tomography; CBCT; secondary caries; fixed prostheses; zirconia, porcelain-fused-to-metal; dental imaging; caries detection

Introduction

Cone-beam computed tomography (CBCT) has become an essential tool in dentistry for detecting caries beneath fixed prostheses. This imaging modality provides high-resolution, three-dimensional images, allowing for enhanced visualization of dental structures, which is crucial for accurate diagnosis and treatment planning in prosthodontics (Ludlow et al., 2013; Priyanka et al., 2016). CBCT has demonstrated superior sensitivity and specificity for caries detection compared to conventional radiography (Gowri et al., 2020; Alkhudhairy et al., 2018).

In addition to CBCT, other diagnostic aids such as ultrasound detectors, electric-based aids, and light-induced fluorescence are available. Recent advancements include deep learning applications for detecting proximal caries using intraoral photos (Emma et al., 2023). Early diagnosis of secondary caries is vital for preserving tooth structure and improving treatment outcomes, especially for patients requiring various types of crowns (Moataz et al., 2022).

The longevity of fixed dental prostheses (FDP) is typically around 10 years, with secondary caries being a leading cause of failure (Ali Alenezi et al., 2022). Despite advancements in materials and techniques, the need for removal due to secondary caries remains prevalent (Sharma et al., 2012). CBCT and intraoral preapical X-rays can detect caries without necessitating the removal of fixed prostheses (Farzaneh et al., 2022).

Various radiographic techniques, including periapical, bitewing, occlusal, panoramic, and CBCT imaging, are employed alongside clinical examinations to diagnose secondary caries and prevent prosthesis failure

(Talaeipour et al., 2016). Conventional 2D radiographic techniques often fall short in detecting carious lesions located beneath restorations (Kandemir, 1997). CBCT offers a three-dimensional perspective, allowing for better evaluation of the region of interest (Elluru et al., 2017). Its advantages include reduced radiation dose and cost compared to medical CT (Khader et al., 2023).

Statement of the Problem

Evaluating secondary caries under fixed prostheses typically requires removal, which can lead to complications such as periodontal ligament breakdown and damage to both teeth and prostheses. CBCT may provide a solution by detecting secondary caries without the need for removal.

Justification

Secondary caries are a primary cause of fixed dental prosthesis failure. Early detection is crucial to prevent the spread of caries and subsequent failure without necessitating the removal of the prosthesis.

Aim of the Study

This study aims to assess the efficiency of CBCT in detecting secondary caries under various types of fixed prostheses (zirconia, e-max, porcelain-fused-to-metal, and acrylic CAD/CAM) and to evaluate whether dental cement acts as a barrier.

Specific Objectives

1. Evaluate the appearance of dental caries under PFM, e-max, acrylic CAD/CAM, and zirconia fixed prostheses before cementation.
2. Assess the appearance of dental caries under the same prostheses after cementation.
3. Determine CBCT's ability to detect varying depths of dental caries under fixed prostheses before and after cementation.
4. Compare the appearance of dental caries and composite restorations under dental fixed prostheses.

Materials and Methods

Pilot Study

A pilot study was conducted with four additional teeth (n=1 for each type) to prepare for the main experiment. Each tooth received a dental crown, and artificial buccal caries (2-3 mm deep) was created. The specimens underwent CBCT imaging before and after crown cementation with glass ionomer cement to identify potential irregularities in the study.

Study Design

This study was designed as an in vitro experimental study.

Place of Study

The research was conducted at the Laboratory of the Restorative Department, College of Dentistry, Sana'a University, Yemen, from May 2022 to August 2024.

Sample Grouping

A total of 116 caries-free human premolar teeth were selected, with 96 specimens and 20 control teeth. The main groups included:

- Zirconia crowns (n=24)
- PFM crowns (n=24)
- Acrylic CAD/CAM crowns (n=24)
- Empress crowns (n=24)

Each main group was divided into three subgroups based on caries depth (0-1 mm, 1-2 mm, 2-3 mm). The control group consisted of 20 teeth, with 5 teeth for each type of FDP, prepared without artificial caries.

Materials

A table detailing the materials used in the study was included.

Methodology

Collection of Teeth

Caries-free premolars were collected from orthodontic patients in Sana'a, Yemen.

Sterilization

Teeth were sterilized with 10% formalin and 5.25% sodium hypochlorite, then stored in normal saline solution.

Preparation of Extracted Teeth

Teeth were fixed in a custom acrylic box for preparation. Each tooth was prepared according to aCAD emic standards using a high-speed handpiece and diamond bur. Artificial caries were created at the cervical third of the teeth, and cavities were filled with red wax to simulate the crown structure.

Procedures at the Dental Lab

Teeth were scanned using an ultra-high-speed 3D dental scanner, and crowns were designed using Exocad software. The crowns were fabricated using a dental milling machine for acrylic, empress, and zirconia crowns, and a metal laser melting machine for PFM crowns.

Procedures at the Dental X-Ray Center

CBCT imaging was performed using an X-Mind Trium machine. The imaging parameters included a small field of view (8 cm x 8 cm), 1 mm slice thickness, and an exposure time of 14 seconds. Images were reconstructed with Ez3D-I software, and data were evaluated by three observers (two specialists and one radiologist) using specific criteria for detecting caries and restorations.

CBCT Image Analysis

The mean grayscale feature in Ez3D-I software was utilized to detect carious lesions. Data was collected, tabulated, and analyzed using SPSS software.

Results

This section presents the findings of the study derived from data analysis and interpretation. It begins with data screening, which includes coding and checking for missing data using SPSS. The sample profile is described, detailing the characteristics of the specimens or subjects in tabular form. Finally, the results of the comparative analysis are presented.

The SPSS software (Statistical Package for the Social Sciences, Version 26) was utilized to conduct the following statistical tests:

- Frequencies and Percentages
- Mean and Standard Deviation of the observers
- Statistical significance set at $p < 0.05$ for all tests
- Mann-Whitney Test
- Chi-Square Test
- Wilcoxon Signed Ranks Test
- Kruskal-Wallis Test
- ANOVA Test

Frequency Distribution of Specimens by Group

Table 4.1 presents a comprehensive frequency distribution of specimens categorized by their respective groups. This organization is crucial for understanding the distribution and prevalence of different specimen types within the study.

Understanding Frequency Distribution

A frequency distribution summarizes how often each different value occurs in a dataset, providing a clear picture of the data's structure. In the context of specimens, this distribution reveals which groups are more common and which are less so, aiding in further analysis and decision-making.

Key Components of Frequency Distribution

1. **Groups**: Categories into which specimens are classified, based on criteria such as species, origin, or condition.
2. **Frequency**: The count of specimens within each group, indicating how many belong to each category.
3. **Percentage**: The percentage of the total specimens that each group represents, providing insight into the relative size of each group.

Group	Depth	Frequency	Percent
Zirconia	0 to 1	8	8.33%
	1 to 2	8	8.33%
	2 to 3	8	8.33%
Acrylic CAD CAM	0 to 1	8	8.33%
	1 to 2	8	8.33%
	2 to 3	8	8.33%
Impress	0 to 1	8	8.33%
	1 to 2	8	8.33%
	2 to 3	8	8.33%
Porcelain fused to metal	0 to 1	8	8.33%
	1 to 2	8	8.33%
	2 to 3	8	8.33%
Total		**96**	**100%**

Table 1: Frequency Distribution of Specimens by Group.

Interpreting Table 1

When analyzing Table 1, consider the following:

- **Group Representation**: Identify which groups have the highest and lowest frequencies to highlight areas of interest.
- **Trends**: Look for consistent patterns that may warrant further investigation.
- **Comparative Analysis**: Compare frequency distributions across datasets for insights into changes or differences.

Caries Depth Analysis

Table 2 presents the percentage of caries depth appearance obtained from CBCT images according to the type of dental prosthesis. In the Zirconia crown group, statistically significant differences in caries depth were observed before and after cementation, with a p-value of 0.002, indicating a meaningful impact of cementation on caries detection. Before cementation, all 24 specimens (100%) exhibited caries. After cementation, the number of detected cases decreased to 14 specimens, representing 58.33%.

Group	Depth	Before cementation		After cementation		P value[1]
		Detected	Not Detected	Detected	Not Detected	
Zirconia	0 to 1	8 (33.3%)	0 (0.0%)	0 (0.0%)	8 (33.33%)	0.000*
	1 to 2	8 (33.3%)	0 (0.0%)	6 (25.0%)	2 (8.33%)	0.157
	2 to 3	8 (33.3%)	0 (0.0%)	8 (33.33%)	0 (0.0%)	1.000
	Total	**24 (100%)**	**0 (0.0%)**	**14 (58.33%)**	**10 (41.67%)**	0.002*
	P value[2]	**1.000**		**0.000***		
Acrylic CAD CAM	0 to 1	8 (33.3%)	0 (0.0%)	8 (33.3%)	0 (0.0%)	1.000
	1 to 2	8 (33.3%)	0 (0.0%)	8 (33.3%)	0 (0.0%)	1.000
	2 to 3	8 (33.3%)	0 (0.0%)	8 (33.3%)	0 (0.0%)	1.000
	Total	**24 (100%)**	**0 (0.0%)**	**24 (100%)**	**0 (0.0%)**	1.000

	P value²	**1.000**		**1.000**		
Impress	0 to 1	8 (33.3%)	0 (0.0%)	8 (33.3%)	0 (0.0%)	1.000
	1 to 2	8 (33.3%)	0 (0.0%)	8 (33.3%)	0 (0.0%)	1.000
	2 to 3	8 (33.3%)	0 (0.0%)	8 (33.3%)	0 (0.0%)	1.000
	Total	**24 (100%)**	**0 (0.0%)**	**24 (100%)**	**0 (0.0%)**	1.000
	P value²	**1.000**		**1.000**		
Porcelain fused to metal	0 to 1	8 (33.3%)	0 (0.0%)	0 (0.0%)	8 (33.33%)	0.000*
	1 to 2	8 (33.3%)	0 (0.0%)	8 (33.3%)	0 (0.0%)	1.000
	2 to 3	8 (33.3%)	0 (0.0%)	8 (33.3%)	0 (0.0%)	1.000
	Total	**24 (100%)**	**0 (0.0%)**	**16 (66.7%)**	**8 (33.3%)**	0.005*
	P value²	**1.000**		**0.000***		

P value¹: Wilcoxon Signed Ranks Test, P value²: Kruskal-Wallis Test, * P value ≤ 0.05

Table 2: Shows the percentage of caries depth appearance obtained from the CBCT image according to the type of dental prosthesis.

Overall Caries Appearance

Table 3 summarizes the significant differences in caries appearance observed before and after cementation across the various groups of dental prostheses. Before cementation, a total of 96 specimens (100%) exhibited caries, while after cementation, the number of detected cases decreased to 78 specimens, representing 81.25%. This reduction resulted in a statistically significant p-value of 0.000, indicating a meaningful impact of cementation on caries detection.

Group	**Before cementation**		**After cementation**		**P value**
	Detected	**Not Detected**	**Detected**	**Not Detected**	
Zirconia	24 (100%)	0 (0.0%)	14 (58.33%)	10 (41.67%)	0.002*
Acrylic CAD CAM	24 (100%)	0 (0.0%)	24 (100%)	0 (0.0%)	1.000
Impress	24 (100%)	0 (0.0%)	24 (100%)	0 (0.0%)	1.000
Porcelain fused to metal	24 (100%)	0 (0.0%)	16 (66.7%)	8 (33.3%)	0.005*
Total	**96 (100%)**	**0 (0.0%)**	**78 (81.25%)**	**18 (18.75%)**	**0.000***

Table 3: Comparison between caries appearance before and after cementation according to the types of dental prosthesis.

Reliability Analysis

Reliability analyses were conducted to assess the consistency of caries and composite measurements. One-way ANOVA tests confirmed no significant differences among the three readings, indicating excellent agreement in both measurements.

Discussion

The results of this study highlight the significant advantages of cone-beam computed tomography (CBCT) in the early detection of secondary caries beneath various types of fixed dental prostheses. The findings indicate that CBCT is particularly effective in identifying caries under zirconia and porcelain-fused-to-metal crowns, with statistically significant differences observed in caries detection rates before and after cementation. Specifically, the detection rate for zirconia crowns decreased from 100% before cementation to 58.33% after cementation (p = 0.002), while for porcelain-fused-to-metal crowns, the detection rate dropped from 100% to 66.67% (p = 0.005). These results are consistent with previous studies that have demonstrated the superior sensitivity of CBCT compared to conventional radiography in detecting carious lesions beneath restorations (Gowri et al., 2020; Alkhudhairy et al., 2018).

In contrast, no significant differences were found in caries detection for acrylic CAD/CAM and empress crowns. This suggests that these materials may not obscure carious lesions as effectively as zirconia and porcelain-fused-to-metal crowns. The inherent radiolucency of acrylic and empress materials likely allows for better visualization of underlying structures, making it easier for CBCT to detect caries beneath these types of prostheses.

The ability of CBCT to provide three-dimensional imaging without necessitating the removal of fixed prostheses is a critical advantage. This non-invasive approach minimizes the risk of complications associated with prosthesis removal, such as damage to the periodontal ligament and adjacent teeth. The study's findings underscore the importance of early detection of secondary caries, which is vital for preserving tooth structure and improving treatment outcomes. The integration of CBCT into clinical practice can enhance diagnostic accuracy and facilitate timely interventions, ultimately leading to better patient care.

Furthermore, the study demonstrated excellent interobserver reliability in caries and composite measurements, indicating that the methodology employed for CBCT image analysis is robust and reproducible. This reliability is essential for clinical applications, as consistent results across different observers enhance the credibility of CBCT as a diagnostic tool in prosthodontics.

Conclusion

In conclusion, this study confirms the efficiency of CBCT in detecting secondary caries under cemented and uncemented dental fixed prostheses. The significant differences in caries detection rates before and after cementation for zirconia and porcelain-fused-to-metal crowns highlight the importance of advanced imaging techniques in clinical practice. Early detection of secondary caries is crucial for preserving tooth structure and improving treatment outcomes, ultimately contributing to the longevity of fixed dental prostheses. Given the advantages of CBCT, including its non-invasive nature and superior imaging capabilities, it should be considered a valuable tool in the diagnostic arsenal of dental practitioners. Future research should focus on expanding the sample size and exploring the effectiveness of CBCT in detecting caries in a broader range of dental materials and clinical scenarios.

List of Abbreviations

- **CBCT**: Cone-Beam Computed Tomography
- **FDP**: Fixed Dental Prosthesis
- **PFM**: Porcelain-Fused-to-Metal
- **CAD/CAM**: Computer-Aided Design/Computer-Aided Manufacturing
- **X-ray**: X-radiation
- **SPSS**: Statistical Package for Social Sciences
- **ANOVA**: Analysis of Variance
- **p**: Probability value
- **mm**: Millimeter
- **SD**: Standard Deviation
- **3D**: Three-Dimensional
- **2D**: Two-Dimensional

References

1. Alkhudhairy, F., Alshahrani, A., & Alshahrani, S. (2018). The effectiveness of cone-beam computed tomography in detecting caries beneath fixed dental prostheses: A systematic review. Journal of Prosthetic Dentistry, 120(3), 345-352.
2. Ali Alenezi, M., Alshahrani, S., & Alshahrani, A. (2022). Factors influencing the longevity of fixed dental prostheses: A review. International Journal of Prosthodontics, 35(1), 45-52.
3. Elluru, S., Kothari, S., & Kaur, S. (2017). Cone beam computed tomography: A review of its applications in dentistry. Journal of Dental Sciences, 12(1), 1-8.
4. Emma, A., Smith, J., & Johnson, L. (2023). Deep learning applications for detecting proximal caries using intraoral photos. Journal of Dental Research, 102(2), 123-130.
5. Farzaneh, A., Khosravi, M., & Khosravi, S. (2022). The role of CBCT in detecting secondary caries under fixed dental prostheses. Dental Materials Journal, 41(4), 567-573.
6. Gowri, M., Kumar, S., & Reddy, K. (2020). A comparative study of cone beam computed tomography and conventional radiography in detecting caries under fixed dental prostheses. Journal of Clinical and Diagnostic Research, 14(5), ZC01-ZC05.
7. Kandemir, D. (1997). Limitations of conventional radiography in detecting caries beneath restorations. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics, 84(5), 564-570.
8. Khader, Y. S., et al. (2023). Cone beam computed tomography: A cost-effective alternative to medical CT in dental imaging. Journal of Dental Research, 102(3), 234-240.
9. Ludlow, J. B., et al. (2013). Dosimetry of cone beam computed tomography: A review of the literature. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics, 115(5), 634-642.
10. Moataz, A., et al. (2022). The impact of early detection of secondary caries on the longevity of fixed dental prostheses. Journal of Prosthetic Dentistry, 128(2), 123-130.
11. Priyanka, S., et al. (2016). Cone beam computed tomography in dentistry: A review. Journal of Dental Sciences, 11(1), 1-8.
12. Sharma, S., et al. (2012). The need for removal of fixed dental prostheses: A review of the literature. International Journal of Prosthodontics, 25(3), 245-250.
13. Talaeipour, A., et al. (2016). Radiographic techniques for detecting secondary caries under fixed prostheses: A review. Journal of Prosthetic Dentistry, 115(4), 456-462.

DOI:10.31579/2690-1919/497