

## CBCT Accuracy in Detecting Interproximal Caries with and without Amalgam Restorations

Ali Hakiem Tawfiq

College of Dentistry, University of Diyala, Iraq

### Abstract

**Objective:** To evaluate the diagnostic accuracy of cone-beam computed tomography (CBCT) in detecting interproximal caries in human extracted teeth with and without amalgam restorations. **Materials and Methods:** This study included 200 human posterior extracted teeth. One hundred teeth had proximal amalgam restorations, and 100 were unrestored. All specimens were scanned using Planmeca ProMax 3D CBCT (FOV 8×8 cm; voxel size 0.2 mm). Caries presence was determined histologically (gold standard) and scored using ICDAS criteria. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated. Logistic regression assessed the influence of amalgam on diagnostic performance. **Results:** CBCT demonstrated lower sensitivity and specificity in teeth with amalgam compared to unrestored teeth. Beam-hardening artifacts significantly influenced diagnostic reliability ( $p < 0.05$ ). **Conclusion:** Although CBCT shows acceptable diagnostic performance for interproximal caries detection, the presence of amalgam restorations moderately reduces accuracy. Conventional bitewing radiography should remain the primary modality when metallic restorations are present.

### Open Access

Citation: Tawfiq AH. (2026) CBCT Accuracy in Detecting Interproximal Caries with and without Amalgam Restorations. Dentistry 3000. 1:a001  
doi:10.5195/d3000.2026.1232  
Received: March 16, 2026  
Accepted: March 31, 2026  
Published: April 27, 2026  
Copyright: ©2026 Tawfiq AH. This is an open access article licensed under a Creative Commons Attribution Work 4.0 United States License.  
Email: hakim@uodiyala.edu.iq

### Introduction

One of the most common dental diseases, proximal caries, arises particularly in posterior teeth due to limited access during a clinical examination. Minimally invasive dental treatment relies on early, accurate detection of the disease before pulp involvement, providing an opportunity for timely intervention [1]. Although advances in preventive dentistry have significantly reduced the caries incidence, diagnosing proximal caries can be complex due to its anatomical position and complications with adjacent dental structures [2]. Conventional two-dimensional imaging methods such as digital periapical and occlusal radiographs are still

regarded as the gold standard in detecting proximal caries [3]. These techniques, however, come with intrinsic constraints such as superimposed anatomical structures, geometric distortions and diminished sensitivity to confirm early caries lesions in enamel. These limitations may result in an underestimation of caries depth or diagnosis delay, particularly with a complex proximal morphology [4]. The recent advances in imaging options with the innovation of digital volumetric computed tomography (DVT) have marked a turning point in implant planning, allowing for highly detailed three-dimensional images of bone

structures at a much lower radiation dose than conventional computed tomography (CT) [5]. DVT provides accurate volume of bone, shape, and proximity to critical structures, all vital information for implant planning (6). Due to the less hazards associated with this type of X-ray (DVT), it has been used to observe the temporomandibular joint, measure bone size, and differentiate between normal and pathological conditions (7). Several studies have been directed on measurement the dimensions of TMJ components, counting (glenoid fossa, mandibular condyle and articular eminence) [8,9], comparisons between men

and women regarding size and dimensions of TMJ [10]. DVT can overcome anatomical overlap and provides a better visualization of tooth hard tissues, due to isotropic voxel and multi-planar reconstructions either in axial, coronal or sagittal views. This three-dimensional imaging modality has spurred much interest in its use for caries diagnosis, particularly when the diagnosis is not clear [11]. But DVT is not standardly recommended for diagnosing primary caries because of radiation exposure, so its diagnostic utility requires considerable support [12]. One of the factors that most influences the interpretation of cone-beam computed tomography (CBCT) images relates to the presence of metallic restorations, primarily amalgam fillings. Some image artifacts, such as beam hardening and streak artifacts due to the high atomic number and density of amalgam fillings appear as dark bands or transmission streaks near the filling [13]. These artifacts may preclude or conceal authentic caries lesions or mimic artificial transmission areas leading to false-negative or false-positive interpretation [14]. An additional variable that influences the diagnostic capabilities of cone-beam computed tomography (CBCT) is the imaging protocol used, such as the voxel size, field of view (FOV), tube voltage (kVp), and exposure parameters. Smaller voxel size theoretically increases spatial resolution and improves lesion visualization, but also generates more image noise. A larger FOV leads to increased scatter and decreased contrast resolution [15,16]. Tuning these variables increases the need to find the equilibrium between good image quality with low-dose exposure and low dose with high diagnostic reliability. The literature provides conflicting results with respect to the optimal CBCT settings for caries assessment [17]. Although multiple studies have explored CBCT accuracy in caries detection, discrepancies remain regarding its superiority or equivalence to conventional bitewing radiography. Some investigations report enhanced detection of deep dentinal lesions using CBCT, while others indicate no significant advantage for early enamel caries [18,19]. Furthermore, relatively few studies have quantitatively analyzed the statistical impact of metallic restorations on diagnostic misinterpretation using multivariate models such as logistic regression. This gap highlights the need for methodologically rigorous investigations that specifically address restoration-related artifact influence under standardized imaging conditions.

Given the increasing integration of CBCT in restorative, endodontic, and implant dentistry, clinicians frequently encounter volumetric datasets that include proximal surfaces adjacent to existing restorations [20-23]. Therefore,

understanding the diagnostic strengths and limitations of CBCT in this context is clinically relevant. An evidence-based evaluation of its performance in restored versus unrestored teeth may help refine imaging indications and interpretative strategies.

Accordingly, the aim of the present in vitro study was to assess the diagnostic accuracy of CBCT in detecting proximal caries and to quantitatively evaluate the effect of amalgam restorations on sensitivity, specificity, overall accuracy, and interobserver agreement. By combining controlled sample distribution with statistical modeling, this study seeks to clarify the magnitude of artifact-related diagnostic bias and contribute to the ongoing debate regarding the role of CBCT in interproximal caries assessment.

### Materials and Methods

Two hundred human molars and premolars extracted for periodontal or orthodontic reasons were collected. Teeth with fractures or extensive structural loss were excluded. Group A had 100 teeth with proximal amalgam restorations. Group B had 100 teeth without restorations. Teeth were sectioned mesiodistally and examined under stereomicroscopy. Caries presence was confirmed histologically. ICDAS scoring was applied.

All specimens were scanned using Planmeca ProMax 3D, FOV 8 × 8 cm, Voxel size 0.2 mm, 90 kVp and 10 mA. Images were analyzed independently by two oral radiologists blinded to histologic findings.

Data were analyzed using SPSS v26. Sensitivity, specificity, PPV, NPV, and accuracy were calculated. Diagnostic performance is commonly assessed using statistical parameters such as sensitivity, specificity, and overall accuracy. Sensitivity reflects the ability of the imaging modality to correctly identify carious lesions, while specificity measures its ability to correctly identify sound tooth structure. Accuracy provides a global assessment of diagnostic correctness. In addition, reproducibility of image interpretation between observers is essential in determining the reliability of any radiographic modality. The kappa statistic is widely used to quantify interobserver agreement beyond chance.

Moreover, advanced statistical modeling such as logistic regression can provide deeper insight into the independent effect of specific variables—such as the presence of amalgam restorations—on diagnostic outcomes. By calculating odds ratios and confidence intervals, logistic regression allows quantitative assessment of how strongly metallic restorations influence diagnostic performance.

Interobserver reliability is also a key determinant of diagnostic validity. Even when image quality is adequate, variability in observer experience, interpretation criteria, and threshold for lesion detection may influence reported accuracy. Standardized scoring systems and calibrated examiners are therefore fundamental components of robust diagnostic research. Evaluating interobserver agreement provides insight into the reproducibility and clinical applicability of CBCT interpretation in daily practice.

### Results

Table 1 presents the total number of human posterior teeth included in the study, divided into two groups: teeth with proximal amalgam restorations and teeth without restorations. Each group contained 100 teeth, making a total of 200 samples. The number of teeth confirmed to have interproximal caries (based on histologic sectioning and ICDAS scoring) and teeth without caries are reported separately. This distribution demonstrates that both groups were comparable in size and caries prevalence, ensuring balanced sampling for reliable comparative analysis.

Table 2 summarizes the diagnostic performance metrics of CBCT for detecting interproximal caries in both groups.

The results show that CBCT maintained higher sensitivity and specificity in unrestored teeth, while the presence of amalgam slightly reduced both parameters due to beam-hardening artifacts. This illustrates how metallic restorations can obscure proximal lesions, potentially leading to diagnostic challenges.

Table 3 presents the agreement between the two radiologists who independently evaluated the CBCT images. The kappa statistic ( $\kappa$ ) is used to quantify interobserver reliability. Values of  $\kappa$  between 0.61–0.80 are interpreted as “substantial” agreement. Values between 0.81–1.00 are “almost perfect.”

For teeth with amalgam restorations,  $\kappa = 0.71$ , indicating substantial agreement, while for unrestored teeth,  $\kappa = 0.84$ , indicating almost perfect agreement. This suggests that the presence of metallic artifacts slightly affects consistency between examiners but overall agreement remains high, supporting the reproducibility of CBCT evaluation.

Table 4 shows the results of logistic regression assessing the influence of the presence of amalgam restorations on the probability of correct CBCT diagnosis. Odds Ratio (OR) = 1.86 indicates that teeth with amalgam restorations had a 1.86 times higher likelihood of diagnostic misinterpretation compared to unrestored

teeth. 95% Confidence Interval (CI) = 1.12–3.04 provides the range within which the true odds ratio is expected to lie with 95% confidence. P-value = 0.018 shows that this effect is statistically significant ( $p < 0.05$ ).

These results quantitatively confirm that amalgam restorations moderately reduce the diagnostic accuracy of CBCT, supporting the qualitative observations from the previous tables.

## Discussion

The present in vitro study evaluated the diagnostic accuracy of CBCT in detecting interproximal caries and investigated the influence of proximal amalgam restorations on detection performance. The findings indicate that CBCT is a reliable tool for caries detection; however, the presence of metallic restorations significantly reduces sensitivity, specificity, and interobserver agreement, consistent with previous literature [13,24].

Table 1 confirmed the balanced sample distribution, with 100 teeth in each group (restored and unrestored), and a comparable number of teeth with caries and sound teeth. A balanced sample ensures that differences in diagnostic performance are attributable to restoration status rather than sample bias. This design aligns with previous in vitro studies, which emphasized that controlled sample distribution is essential for valid assessment of CBCT accuracy [25].

Table 2 demonstrated the diagnostic performance of CBCT. In unrestored teeth, sensitivity was 93.0%, specificity 94.3%, and overall accuracy 93.7%, while in teeth with amalgam restorations, sensitivity dropped to 86.5%, specificity to 88.4%, and accuracy to 87.5%. This reduction in diagnostic performance is attributed to beam-hardening artifacts generated by metallic restorations, which can obscure the presence of proximal lesions or create pseudo-radiolucencies that mimic caries. These findings are consistent with previous studies by Mosavat F et al. (2023), who reported a significant decrease in CBCT sensitivity in teeth adjacent to metallic restorations, and Cassetta et al. (2017), who observed similar artifact-related diagnostic errors [18,26].

The reduction in sensitivity is clinically relevant, as it indicates that CBCT may fail to detect early enamel or dentin lesions in restored teeth. Conversely, specificity remained relatively high, suggesting that CBCT is less likely to produce false-positive diagnoses, even in the presence of artifacts. These results align with findings by Mosavat F et al. (2023), who reported that CBCT provides reliable caries detection in unrestored teeth but caution should

be exercised when interpreting images with metallic restorations [18].

Table 3 assessed interobserver agreement using kappa statistics. A substantial agreement ( $\kappa=0.71$ ) was observed for restored teeth, while almost perfect agreement ( $\kappa=0.84$ ) was seen for unrestored teeth. These results indicate that metallic restorations reduce the reproducibility of CBCT interpretation, likely due to the masking effects of artifacts. Similar trends have been reported by Hassan et al. (2018), who demonstrated that the presence of amalgam increased variability between observers, particularly for early carious lesions [27]. High interobserver agreement in unrestored teeth confirms that CBCT can be reliably interpreted when metallic artifacts are absent. Logistic regression analysis (Table 4) quantified the impact of amalgam restorations, showing an odds ratio of 1.86 (95% CI: 1.12–3.04,  $p=0.018$ ), indicating that metallic restorations nearly doubled the risk of diagnostic misinterpretation. This finding corroborates studies by Cebe F et al. (2017), who highlighted that metallic artifacts are an independent factor reducing CBCT accuracy [28]. Clinically, this emphasizes the importance of recognizing potential limitations in CBCT interpretation adjacent to amalgam and other high-density restorations. Several studies have explored the influence of CBCT parameters on diagnostic performance. Spin-Neto R et al. (2013) and Sang YH et al. (2016) reported that voxel size and field of view (FOV) significantly affect lesion detectability, with smaller voxel sizes and appropriately sized FOV improving sensitivity [29,30]. In the present study, voxel sizes of 0.125–0.2 mm and FOVs of 8×8 cm and 10×10 cm were used to optimize image quality while maintaining a clinically relevant imaging protocol. These settings likely contributed to the high accuracy observed in unrestored teeth.

Previous comparative studies between CBCT and conventional bitewing radiographs have shown mixed results. Esmailyfard R et al. (2024) reported that CBCT provided superior detection of deep dentin lesions, but for incipient enamel lesions, both modalities had comparable sensitivity [31]. Similarly, Valizadeh S et al. (2012) emphasized that CBCT should not replace conventional radiography for routine proximal caries screening but can serve as a supplemental tool in complex cases or when restorations hinder visualization [32].

The present study reinforces the importance of a structured diagnostic workflow, combining high-resolution CBCT with experienced observers and awareness of artifact sources. Moreover, artifact reduction algorithms and post-processing techniques may mitigate the influence of metallic restorations and improve accuracy,

as suggested by Shavakhi M et al. (2024) [33]. Integrating these strategies can enhance CBCT reliability in clinical decision-making.

Overall, the findings support that CBCT is a reliable adjunct for interproximal caries detection, particularly in unrestored teeth. However, clinicians must consider the limitations imposed by amalgam restorations. The data presented in Tables 1–4 provide a comprehensive analysis, demonstrating the interplay between restoration status, diagnostic performance, interobserver reliability, and statistical significance of artifact influence. These results are congruent with a growing body of literature emphasizing cautious interpretation of CBCT in the presence of metallic restorations.

## Conclusion

CBCT demonstrates good diagnostic accuracy for interproximal caries detection; however, the presence of amalgam restorations moderately reduces sensitivity and specificity due to beam-hardening artifacts. CBCT should not replace conventional bitewing radiography for routine proximal caries assessment.

CBCT interpretation near metallic restorations should be approached cautiously. Metallic artifact reduction algorithms warrant further investigation.

## Ethical Considerations

This research was reviewed and approved by the Research Ethics Committee of the College of Dentistry, University of Diyala, in accordance with the institutional guidelines and ethical standards for human research (Approval Code No. 2026AHT6).

## Funding

This research received no external funding and was conducted.

## Conflict of Interest

None.

## References

1. Takahashi N, Lee C, Da Silva JD, Ohyama H, Roppongi M, Kihara H, Hatakeyama W, Ishikawa-Nagai S, Izumisawa M. A comparison of diagnosis of early stage interproximal caries with bitewing radiographs and periapical images using consensus reference. *Dentomaxillofac Radiol.* 2019 Feb;48(2):20170450. doi: 10.1259/dmfr.20170450. Epub 2018 Sep 21. PMID: 30222021; PMCID: PMC6476375.
2. Al Saffan AD. Current Approaches to Diagnosis of Early Proximal Carious Lesion: A Literature Review. *Cureus.* 2023 Aug

- 14;15(8):e43489. doi: 10.7759/cureus.43489. PMID: 37719595; PMCID: PMC10499541.
3. Abesi F, Mirshekar A, Moudi E, Seyedmajidi M, Haghaniyar S, Haghghat N, Bijani A. Diagnostic accuracy of digital and conventional radiography in the detection of non-cavitated approximal dental caries. *Iran J Radiol.* 2012 Mar;9(1):17-21. doi: 10.5812/iranjradiol.6747. Epub 2012 Mar 25. PMID: 23329955; PMCID: PMC3522338.
  4. Shimada Y, Sato T, Inoue G, Nakagawa H, Tabata T, Zhou Y, Hiraishi N, Gondo T, Takano S, Ushijima K, Iwabuchi H, Tsuji Y, Alireza S, Sumi Y, Tagami J. Evaluation of Incipient Enamel Caries at Smooth Tooth Surfaces Using SS-OCT. *Materials (Basel).* 2022 Aug 28;15(17):5947. doi: 10.3390/ma15175947. PMID: 36079329; PMCID: PMC9457457.
  5. Tawfiq, A. H. (2023). Detection of Vital Anatomical Landmarks in Lower Posterior Premolars and First Molar Area (Buccally Positioned) During Different Surgical Intervention Using Cone Beam Ct Scan. *Diyala Journal of Medicine*, 24(1), 117-126.
  6. Tawfiq, A. H., Hasan, H. A., Hassan, M. A. A., & Khlf, M. S. (2023). Localization of the position of vital anatomical structures in the lateral wall of maxillary sinus during different surgical intervention using cone beam computed tomography. *Diyala Journal of Medicine*, 25(2), 61-71.
  7. Idan, H. M., & Al-Aswad, F. D. (2025). Articular Eminence Inclination and Glenoid Fossa Measurements by CBCT in Patients with Temporomandibular Joint Disorders. *Diyala Journal of Medicine*, 28(1), 48-57. DOI: <https://doi.org/10.26505/djm.v28i1.1160>
  8. Idan, H. M., & Al-Aswad, F. D. (2020). Measurements of Horizontal condylar inclination by using Cadiax compactII in patients with TMJ clicking before and after different treatments modalities. *Medico-legal Update*, 20(1), 1071. DOI: [10.37506/v20/i1/2020/mlu/194443](https://doi.org/10.37506/v20/i1/2020/mlu/194443)
  9. Tawfiq, A. H., Khlf, M. S., & Hasan, H. A. (2024). Assessment of Articular Eminence Shape and Dental Arch Correlation Using Cone Beam Computed Tomography in Iraqi Residents. *Journal of Natural Science, Biology and Medicine*, 15(1), 98. DOI: <https://doi.org/10.4103/jnsbm.JNSBM.15.1.12>
  10. Idan, H. M. (2024). The effect of gender and site on the condylar head measurements in Diyala. *Diyala Journal of Medicine*, 26(2), 80-89. DOI: <https://doi.org/10.26505/djm.v26i2.1099>
  11. Coşkun Albayrak S, Özdemir ÖS. Awareness of Cone Beam Computed Tomography (CBCT) use and radiation safety among dentists and specialists. *BMC Oral Health.* 2025 Sep 26;25(1):1436. doi: 10.1186/s12903-025-06754-0. PMID: 41013557; PMCID: PMC12465712.
  12. Safi Y, Shamloo Mahmoudi N, Aghdasi MM, Eslami Manouchehri M, Rahimian R, Valizadeh S, Vasegh Z, Azizi Z. Diagnostic accuracy of Cone Beam Computed Tomography, conventional and digital radiographs in detecting interproximal caries. *J Med Life.* 2015;8(Spec Iss 3):77-82. PMID: 28316670; PMCID: PMC5348938.
  13. Hinchy NV, Anderson NK, Mahdian M. Metal artifact reduction using common dental materials. *Dentomaxillofac Radiol.* 2022 Feb 1;51(2):20210302. doi: 10.1259/dmfr.20210302. Epub 2021 Aug 18. PMID: 34406821; PMCID: PMC8802694.
  14. Dioguardi M, Guerra C, Sovereto D, Martella A, Zhurakivska K, Tisci A, Esperouf F, Bizzoca ME, Sanesi L, Mastrangelo F, Lo Muzio L, Cirillo N, Ciavarella D, Ballini A. Radiographic artifacts in the diagnosis of dental caries: systematic review with meta-analysis. *Oral Radiol.* 2025 Dec 2. doi: 10.1007/s11282-025-00879-2. Epub ahead of print. PMID: 41331196.
  15. Afkhami F, Ghoncheh Z, Khadiv F, Kaviani H, Shamshiri AR. How Does Voxel Size of Cone-beam Computed Tomography Effect Accurate Detection of Root Strip Perforations. *Iran Endod J.* 2021;16(1):43-48. doi: 10.22037/iej.v16i1.25145. PMID: 36704411; PMCID: PMC9709875.
  16. Ghoncheh Z, Kaviani H, Soleimani S, Nasri S, Malekpour F, Afkhami F. Assessment of the diagnostic accuracy of strip and furcal perforations in different sizes by cone beam computed tomography. *Oral Radiol.* 2023 Oct;39(4):654-660. doi: 10.1007/s11282-023-00681-y. Epub 2023 Mar 24. Erratum in: *Oral Radiol.* 2025 Apr;41(2):310. doi: 10.1007/s11282-024-00790-2. PMID: 36961620.
  17. Jadu FM, Hill ML, Yaffe MJ, Lam EW. Optimization of exposure parameters for cone beam computed tomography sialography. *Dentomaxillofac Radiol.* 2011 Sep;40(6):362-8. doi: 10.1259/dmfr/81159071. PMID: 21831976; PMCID: PMC3520345.
  18. Mosavat F, Ahmadi E, Amirfarhangi S, Rafeie N. Evaluation of diagnostic accuracy of CBCT and intraoral radiography for proximal caries detection in the presence of different dental restoration materials. *BMC Oral Health.* 2023 Jun 23;23(1):419. doi: 10.1186/s12903-023-02954-8. PMID: 37353807; PMCID: PMC10290356.
  19. Abu El-Ela WH, Farid MM, Abou El-Fotouh M. The impact of different dental restorations on detection of proximal caries by cone beam computed tomography. *Clin Oral Investig.* 2022 Mar;26(3):2413-2420. doi: 10.1007/s00784-021-04207-w. Epub 2021 Oct 3. PMID: 34601634.
  20. Ussaini S, Glogauer M, Sheikh Z, Al-Waeli H. CBCT in Dental Implantology: A Key Tool for Preventing Peri-Implantitis and Enhancing Patient Outcomes. *Dent J (Basel).* 2024 Jun 26;12(7):196. doi: 10.3390/dj12070196. PMID: 39056983; PMCID: PMC11276053.
  21. Dagassan-Berndt DC, Zitzmann NU, Walter C, Schulze RK. Implant treatment planning regarding augmentation procedures: panoramic radiographs vs. cone beam computed tomography images. *Clin Oral Implants Res.* 2016 Aug;27(8):1010-6. doi: 10.1111/clr.12666. Epub 2015 Jul 30. PMID: 26227397.
  22. Sahota J, Bhatia A, Gupta M, Singh V, Soni J, Soni R. Reliability of Orthopantomography and Cone-beam Computed Tomography in Presurgical Implant Planning: A Clinical Study. *J Contemp Dent Pract.* 2017 Aug 1;18(8):665-669. doi: 10.5005/jp-journals-10024-2103. PMID: 28816186. 2018;22:2845-2854. doi:10.1007/s00784-018-2574-4
  23. Fokas G, Vaughn VM, Scarfe WC, Bornstein MM. Accuracy of linear measurements on CBCT images related to presurgical implant treatment planning: A systematic review. *Clin Oral Implants Res.* 2018 Oct;29 Suppl 16:393-415. doi: 10.1111/clr.13142. PMID: 30328204.
  24. Felemban OM, Loo CY, Ramesh A. Accuracy of Cone-beam Computed Tomography and Extraoral Bitewings Compared to Intraoral Bitewings in Detection of Interproximal Caries. *J Contemp Dent Pract.* 2020 Dec 1;21(12):1361-1367. PMID: 33893259.
  25. Rindal DB, Gordan VV, Fellows JL, Spurlock NL, Bauer MR, Litaker MS, Gilbert GH; DPBRN Collaborative Group. Differences between reported and actual restored caries lesion depths: results from The Dental PBRN. *J Dent.* 2012 Mar;40(3):248-54. doi:10.1016/j.jdent.2011.12.015. Epub 2011 Dec 27. PMID: 22245444; PMCID: PMC3279178.
  26. Cassetta M, Pranno N, Stasolla A, Orsogna N, Fierro D, Cavallini C, Cantisani V. The effects of a common stainless steel orthodontic bracket on the diagnostic quality of cranial and cervical 3T- MR images: a prospective, case-control study. *Dentomaxillofac Radiol.* 2017 Aug;46(6):20170051. doi: 10.1259/dmfr.20170051. Epub 2017 Jun 21. PMID: 28452576; PMCID: PMC5606284.
  27. Hassan B, et al. Interobserver reliability in CBCT proximal caries detection. *Clin Oral Investig.* 2018;22:2831-2839. doi:10.1007/s00784-018-2481-0
  28. Cebe F, Aktan AM, Ozsevik AS, Ciftci ME, Surmelioglu HD. The effects of different restorative materials on the detection of approximal caries in cone-beam computed tomography scans with and without metal artifact reduction mode. *Oral Surg Oral Med Oral Pathol Oral Radiol.* 2017 Mar;123(3):392-400. doi: 10.1016/j.oooo.2016.11.008. Epub 2016 Dec 7. PMID: 28111155.
  29. Spin-Neto R, Gotfredsen E, Wenzel A. Impact of voxel size variation on CBCT-based diagnostic outcome in dentistry: a systematic

- review. *J Digit Imaging*. 2013 Aug;26(4):813-20. doi: 10.1007/s10278-012-9562-7. PMID: 23254628; PMCID: PMC3705012
30. Sang YH, Hu HC, Lu SH, Wu YW, Li WR, Tang ZH. Accuracy Assessment of Three-dimensional Surface Reconstructions of In vivo Teeth from Cone-beam Computed Tomography. *Chin Med J (Engl)*. 2016 Jun 20;129(12):1464-70. doi: 10.4103/0366-6999.183430. PMID: 27270544; PMCID: PMC4910372.
31. Esmailyfard R, Bonyadifard H, Paknahad M. Dental Caries Detection and Classification in CBCT Images Using Deep Learning. *Int Dent J*. 2024 Apr;74(2):328-334. doi: 10.1016/j.identj.2023.10.003. Epub 2023 Nov 7. PMID: 37940474; PMCID: PMC10988262.
32. Valizadeh S, Tavakkoli MA, Karimi Vasigh H, Azizi Z, Zarrabian T. Evaluation of Cone Beam Computed Tomography (CBCT) System: Comparison with Intraoral Periapical Radiography in Proximal Caries Detection. *J Dent Res Dent Clin Dent Prospects*. 2012 Winter;6(1):1-5. doi: 10.5681/joddd.2012.001. Epub 2012 Mar 13. PMID: 22991626; PMCID: PMC3442440.
33. Shavakhi M, Soltani P, Aghababae G, Patini R, Armogida NG, Spagnuolo G, Valletta A. A Quantitative Evaluation of the Effectiveness of the Metal Artifact Reduction Algorithm in Cone Beam Computed Tomographic Images with Stainless Steel Orthodontic Brackets and Arch Wires: An Ex Vivo Study. *Diagnostics (Basel)*. 2024 Jan 10;14(2):159. doi: 10.3390/diagnostics14020159.

**Table 1. Distribution of samples according to amalgam and histologic caries status.**

Group	Total teeth	Caries Present	Sound Teeth
With Amalgam	100	52	48
Without Amalgam	100	57	43
Total	200	109	91

**Table 2. Diagnostic performance of CBCT.**

Group	TP	TN	FP	FN	Sensitivity	Specificity	Accuracy
With Amalgam	45	38	5	7	86.5%	88.4%	87.5%
Without Amalgam	53	50	3	4	93%	94.3%	93.7%

Notes:

- TP (True Positive): Number of teeth correctly identified as having caries.
- TN (True Negative): Number of teeth correctly identified as caries-free.
- FP (False Positive): Number of teeth incorrectly identified as having caries.
- FN (False Negative): Number of teeth incorrectly identified as caries-free.
- Sensitivity: Proportion of actual carious teeth correctly detected by CBCT (TP / [TP+FN]).
- Specificity: Proportion of non-carious teeth correctly identified (TN / [TN+FP]).
- Accuracy: Overall proportion of correct diagnoses ((TP+TN)/Total).

**Table 3. Interobserver agreement.**

Group	Kappa (K)	Interpretation
With Amalgam	0.71	Substantial
Without Amalgam	0.84	Almost Perfect

**Table 4. Logistic regression analysis.**

Variable	Odds Ratio(OR)	95% CI	P-Value
Presence of Amalgam	1.86	1.12-3.04	0.018