DENTAL MEDICINE **ORIGINAL PAPERS**

THE ACCURACY OF AI-ASSISTED IMAGING DIAGNOSIS *VERSUS* CONVENTIONAL EVALUATION OF DENTAL PROFESSIONALS

Oana Butnaru[1], Diana Tatarciuc[2*], F. C. Bida[3], Carina Balcoş[4], V. Constantin[5], C. Cojocaru[5], Teona Tudorici[5], G. Rotundu[6], Ana Sîrghe[7], Danisia Haba[8]

"Grigore T. Popa" University of Medicine and Pharmacy Iasi, Romania
Faculty of Dental Medicine,
1. Department of Biophysics
2. Department of Internal Medicine
3. Department of Implantology, Removable Prostheses
4. Department of Oral Health
5. Department of Total Prostheses
6. Department of Periodontology
7. Department of Pediatric Dentistry
8. Department of Dental Radiology
[*]Corresponding author. E-mail: diana.tatarciuc@umfiasi.ro

THE ACCURACY OF AI-ASSISTED IMAGING DIAGNOSIS *VERSUS* CONVENTIONAL EVALUATION OF DENTAL PROFESSIONALS (Abstract): The accurate detection of dental caries is crucial for effective treatment planning and prevention of disease progression. Artificial intelligence (AI) has emerged as a valuable tool in odonto-periodontal imaging, offering potential improvements in diagnostic accuracy compared to traditional methods employed by dental professionals. This study **aimed** to compare the accuracy of AI-assisted odonto-periodontal imaging in detecting dental caries with diagnoses established by general dentists, specialists, and senior specialists. **Materials and methods:** A comparative analytical study was conducted on a sample of 60 dentists categorized into three professional groups-general dentists, specialists, and senior specialists-alongside AI diagnostics using the Planmeca Romexis platform. **Results:** High-quality panoramic radiographs (OPG) representing various carious lesions were analyzed independently by all participants. Statistical analysis was performed using *SPSS version 26.0,* employing chi-square and ANOVA tests to assess differences among groups. Senior specialists and AI reported the highest number of detected lesions, with AI demonstrating a lower standard deviation, indicating greater consistency. The ANOVA test confirmed significant differences in caries detection across groups ($F=18.849$, $p<.001$), highlighting the superior diagnostic performance of AI. **Conclusions:** This study demonstrates the significant advantages of AI-assisted diagnostic tools in dental-periodontal imaging, particularly in the detection of carious lesions. **Keywords**: AI, DENTAL CAVITIES, ORAL DIAGNOSIS, DENTAL IMAGING.

INTRODUCTION

The capacity of human readers to evaluate a wide range of qualitative aspects is restricted, and their performance varies, when it comes to interpreting medical images. On the other hand, AI is able to reliably and consistently assess a wide variety of quantitative characteristics. Diagnostics, prognoses, treatment efficacy, and risk assessment are all areas that can benefit from these imaging biomarkers (1, 2).

The use of AI has revolutionized the dental industry and is now an integral part of patient care. Improved diagnostic imaging, treatment planning, patient management, and workflow optimization are just a few ways it has revolutionized dentistry. Image interpretation, charting automation, and treatment result prediction are all enhanced by it (1). Radiographic and CT scan analysis is made more accurate, allowing for more precise diagnosis of diseases including cavities and bone resorption, thanks to its advanced algorithms. Artificial intelligence (AI) uses predictive analytics to develop individualized treatment plans and optimizes the production of orthodontic devices like aligners. Improving patient outcomes is another benefit of AI's real-time clinical decision assistance and thorough risk evaluations (1-3).

It is now generally acknowledged that radiography may greatly benefit from the integration of AI in order to decrease human error, boost efficiency, and accomplish goals with little to no human intervention (3). Conventional imaging modalities, including X-rays, may not pick up on symptoms of illness that aren't immediately obvious (4). By evaluating radiographs and imaging modalities alone or in combination, AI systems may be able to routinely detect these tiny changes, seemingly with amazing precision (5), enabling prompt intervention (6).

Orthopantomogram (OPG), also known as panoramic radiography, is an essential tool in dentistry and orthodontics, providing a detailed image of the dental and bony structures of the oral cavity. By interpreting an OPG, a specialist can identify a range of dental and bone conditions and abnormalities (7).

Recording the patient's oral health and identifying and diagnosing problematic symptoms, such as cavities, are common recurrent activities in the dental field. Personalized suggestions for preventative and surgical care are the ultimate outcome of this evaluation (8). Visual examination is the gold standard in clinical practice since it is simple to do and yields satisfactory results following dental washing and drying. Despite the fact that educated dentists often have strong intra- and inter-examiner repeatability, inconsistent diagnoses are nonetheless seen frequently in clinical practice, even though diagnostic studies have proved this (3, 9, 10, 11). So, it may be a good idea to use AI approaches for independent verification (12-14).

This study proposes to comparatively evaluate the accuracy of AI-assisted odonto-periodontal imaging diagnosis versus the one established by dentists, specialists and senior specialists.

MATERIALS AND METHODS

The comparative analytical study aimed at assessing the accuracy of AI-assisted dental and periodontal imaging diagnosis versus that established by general dentists, specialists and senior specialists was conducted on a group of 60 dentists selected based on their level of professional training.

Study group:

- **Group 1:** 20 general dentists.
- **Group 2:** 20 specialists
- **Group 3:** 20 senior specialists
- **Group 4:** The artificial intelligence (AI) system used for diagnosis (Planmeca Romexis).

To improve diagnosis accuracy and simplify operations in dental clinics, Planmeca Romexis® incorporates several tools and features into its complete software platform. Using cutting-edge imaging technology and AI, it can identify periodontal diseases and cavities, which are two of its most remarkable features.

When used with Planmeca Emerald® intraoral scanners, the software is compatible with the scanning tip known as Planmeca Cariosity®. In order to identify dental cavities, this set uses radiation-free transillumination technology. Clinicians can see into tooth structure with near-infrared light, which helps them detect early-stage fractures, approximal, occlusal, and secondary cavities. For additional analysis and patient communication, the recorded photos can be saved in the Romexis database.

Dental practitioners benefit from early diagnosis and treatment planning with the help of Planmeca Romexis® software's superior imaging capabilities, which enable the identification of numerous coronal lesions. The method is able to identify a variety of coronal lesions, including:

- calculus deposits
- signs of various dental pathologies and other treatable conditions found in dental radiographs - including hard-to-detect issues such as early-stage cavities or initial signs of periapical radiolucency
- the percentage of carious involvement in the enamel and dentin

The software can identify potential cavities and assist in determining the best treatment plan, such as a filling, an inlay, an onlay, a crown, endodontic treatment, or an extraction. Findings are highlighted with colors and text, providing an easily understandable, independent opinion that helps build patient trust. This enables timely interventions and offers long-term health benefits by improving patient retention.

Selection of cases. Different dento-periodontal diseases (such as periodontitis, interproximal cavities, alveolar bone loss, and periapical lesions) were depicted in six high-quality radiographic pictures (OPG). To make sure the reference diagnosis was legitimate, a senior specialist and an expert in dental imaging had already verified the instances in question.

Participant Intervention. Without seeing the patient's medical history, each participant independently assessed the collection of photos and made a diagnosis based on their findings. A deep learning system trained on comparable data was used to construct the AI diagnostic.

Assessing Performance. All of the dental teams' and the AI's diagnoses were compared to the "gold standard" reference diagnostic.

Statistical analysis. After data collection was complete, *SPSS version 26.0* (IBM, USA) was used for statistical analysis. Frequencies and mean values were used to display the results. It was determined that there were statistically significant variations in the dental-periodontal assessment between the groups using procedures like the chi-square test and ANOVA analysis.

Multiple comparisons on the same data set were corrected statistically using the Bonferroni test because of the small sample size. This method is designed to lessen the likelihood of getting false positive findings because of all the tests that are run. To rule out the possibility of random effects due to multiple comparisons, the Bonferroni procedure was employed to guarantee that the observed group differences are strong and durable. The reliability of the statistical findings is guaranteed in this way. A significance criterion of $p < 0.05$ was established.

RESULTS

The results of the study provide a comparative analysis of the diagnostic accuracy of AI-assisted odonto-periodontal imaging versus that of dentists with different levels of expertise. The findings are presented in terms of diagnostic performance, highlighting the agreement between AI and human evaluations relative to the established reference standard.

Table I provides an overview of dental health by analysing the total number of decayed teeth, enamel cavities, and dentin cavities. For the total number of decayed teeth, values range from a minimum of 0 to a maximum of 19, with a mean of 8.36 and a standard deviation of 4.83, indicating significant variation between cases. Enamel cavities show a lower mean of 2.64, with a range from 0 to 9 and a standard deviation of 2.75, suggesting less enamel involvement compared to dentin cavities. In the case of dentin cavities, the values are higher, with a mean of 5.73 and a maximum of 12, highlighting a more significant dental concern. The high standard deviations across all three categories reflect considerable diversity in the dental health status within the studied group.

TABLE I.
The average values of decayed teeth, enamel cavities, and dentin cavities

	Minimum	Maximum	Mean	Std. Deviation
Decayed teeth	.00	19.00	8.3636	4.82505
Enamel cavities	.00	9.00	2.6364	2.75478
Dentin cavities	.00	12.00	5.7273	2.87453
Valid N (listwise)				

Analysing the percentage distribution of the number of cavities detected by the participants reveals significant differences between professional categories: senior specialists, specialists, general dentists, and AI and data is represented below (tab. II).

TABLE II.
The distribution of the number of detected cavities cases among participant groups.

		Doctors				Total
		Senior specialist	Specialist	Dentist	AI	
Number of teeth cavities	0.00			5.0%		1.5%
	1.00		10.0%	10.0%		6.1%
	2.00		20.0%	5.0%		7.6%
	3.00			5.0%		1.5%
	4.00		5.0%	15.0%		6.1%
	5.00		10.0%	5.0%		4.5%
	6.00			10.0%		3.0%
	7.00	20.0%	5.0%	20.0%		13.6%
	8.00		15.0%	15.0%	33.3%	12.1%
	9.00		20.0%	5.0%		7.6%
	10.00	15.0%	10.0%	5.0%		9.1%
	11.00	15.0%	5.0%		16.7%	7.6%
	12.00				33.3%	3.0%
	13.00	15.0%				4.5%
	17.00	20.0%			16.7%	7.6%
	19.00	15.0%				4.5%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

For senior specialists, a balanced distribution of detected cavities is observed, with notable peaks at 7 and 17 cavities (20% each). This indicates a moderate involvement in detecting more complex cases, along with a uniform distribution of the number of cavities among their patients.

In the case of specialist dentists, the distribution is more balanced, with a peak of 20% for 9 detected cavities. This suggests that these participants evaluated patients with a wide range of dental issues but did not identify all existing carious lesions.

General dentists stand out with a higher proportion of cases involving a significant number of detected cavities, such as 7 and 8 cavities (20% each). This may reflect greater expertise in identifying cavities or increased exposure to patients with severe dental issues.

The AI system recorded the highest proportion of cases with extreme values, such as 8 and 12 detected cavities (33.3% each). These results indicate an enhanced ability to detect the presence of carious lesions.

Overall, the distribution of the number of detected cavities varies significantly depending on the type of participant, suggesting differences in professional experience, clinical approach, or the specific patient population examined. These differences highlight the importance of professional context in analyzing clinical data.

The Chi-Square analysis conducted to assess the relationship between the number of detected cavities and the type of participant revealed a statistically significant association. The Pearson Chi-Square test yielded a value of 86.075, with 45 degrees of freedom and a significance value of .000, indicating a strong relationship between the variables and rejecting the null hypothesis that there is no connection between the doctors and the number of detected cavities. These results were confirmed by the Likelihood Ratio test, which produced similar values (86.846) and an identical asymptotic significance (p = .000) (tab. III).

TABLE III.

The relationship between the number of detected cavities and the type of participant.

	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	86.075a	45	.000
Likelihood Ratio	86.846	45	.000
No. of Valid Cases	66		
64 cells (100.0%) have expected count less than 5. The minimum expected count is .09.			

A comparative evaluation of the average values of detected decayed teeth based on the participant groups was conducted (tab. IV).

Senior specialists had the highest average number of detected decayed teeth, 12.75, indicating significant involvement in evaluating more complex cases. The variability within this group is relatively high, with a standard deviation (SD) of 4.31, and the 95% confidence interval for the mean ranges from 10.73 to 14.77. The minimum number of decayed teeth detected in this group is 7, while the maximum is 19, indicating a wide range of case severity.

Specialists, on the other hand, recorded a lower average number of detected decayed teeth, at 6.10, with moderate variability (a standard deviation of 3.45) and a confidence interval of 4.49 to 7.71. The minimum number of detected decayed teeth in this group is 1, while the maximum is 11.

TABLE IV.

Comparative evaluation of the average number of detected teeth based on participant groups

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Senior specialist	20	12.750	4.31491	.96484	10.7306	14.7694	7.00	19.00
Specialist	20	6.1000	3.44735	.77085	4.4866	7.7134	1.00	11.00
General dentist	20	5.3500	2.87045	.64185	4.0066	6.6934	.00	10.00
AI	6	11.3333	3.32666	1.35810	7.8422	14.8244	8.00	17.00
Total	66	8.3636	4.82505	.59392	7.1775	9.5498	.00	19.00

General dentists registered the lowest average number of detected decayed teeth, at 5.35, indicating a lower focus on identifying multiple caries. Variability in this group is lower (a standard deviation of 2.87), with a confidence interval for the mean ranging from 4.01 to 6.69. Extreme values in this group range from 0 to 10, reflecting less severe cases compared to other categories.

In the case of AI, the average number of detected decayed teeth is high, at 11.33, compared to that of senior specialists. However, the small sample size for this group (N=6) limits the robustness of the conclusions. The standard deviation is 3.33, and the confidence interval for the mean ranges from 7.84 to 14.82. Extreme values in this group range from 8 to 17, suggesting a high severity level of the analyzed cases.

Overall, the average number of detected decayed teeth across all categories is 8.36, with a standard deviation of 4.83, indicating significant variability between groups. The values range from 0 to 19 decayed teeth, with a confidence interval for the mean ranging from 7.18 to 9.55.

These results reflect the diversity of the analyzed cases and highlight the differences between groups in terms of professional experience and the types of patients evaluated.

The ANOVA test results show statistically significant differences in the number of detected decayed teeth among the participant categories. The high F-value (18.849) and $p < .001$ indicate that the type of participant has a significant effect on the number of detected decayed teeth. To better understand which groups, differ from each other, a post hoc analysis (e.g., Tukey test) would be useful to identify specific group pairs with significant differences.

TABLE V.

ANOVA test for identifying differences in detected caries among participant groups

Decayed teeth					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	721.839	3	240.613	18.849	.000
Within Groups	791.433	62	12.765		
Total	1513.273	65			

The detection of enamel caries can be challenging, as they are often asymptomatic in the early stages and may require a combination of careful visual examination and detailed interpretation of radiographic images, such as orthopantomograms or periapical radiographs, to be accurately identified.

Descriptive analysis indicates significant differences between the participant groups (tab. VI).

TABLE 6.

Comparative evaluation of the average values recorded across groups.

	N	**Mean**	**Std. Deviation**	**Std. Error**	**95% Confidence Interval for Mean**		**Minimum**	**Maximum**
					Lower Bound	**Upper Bound**		
Senior specialist	20	4.7500	2.80741	.62776	3.4361	6.0639	.00	9.00
Specialist	20	1.5000	1.73205	.38730	.6894	2.3106	.00	5.00
General dentist	20	.8000	1.23969	.27720	.2198	1.3802	.00	5.00
AI	6	5.5000	2.25832	.92195	3.1300	7.8700	2.00	9.00
Total	66	2.6364	2.75478	.33909	1.9592	3.3136	.00	9.00

Senior specialists and AI reported the highest average number of cases (4.75 and 5.50, respectively), while specialist and general dentists recorded lower averages (1.50 and 0.80). The confidence intervals for the means of AI and senior specialists partially overlap, suggesting similarities in case detection. However, AI had the highest overall average and moderate variability, indicating greater consistency in reporting compared to senior specialists.

The dispersion of data varies significantly among the groups. Specialist and general dentists show low variability, indicating greater consistency in their results but also a possible underestimation of cases. In contrast, senior specialists exhibited a higher standard deviation (2.81), reflecting greater variability in caries detection. AI, with a standard deviation of 2.26, demonstrated relatively consistent detection, comparable to that of senior specialists in terms of maximum values.

Based on the minimum and maximum values, AI and senior specialists detected the most severe cases (up to 9 enamel caries), whereas specialists and general dentists reported a maximum of 5 cases. These findings suggest that AI and senior specialists are more sensitive in identifying extreme cases, while specialists and general dentists tend to have a more conservative approach. The differences between groups highlight AI's potential to complement clinical diagnosis, especially in complex cases.

The ANOVA test results show statistically significant differences between the participant groups) (tab. VII).

TABLE VII.
Association of periodontal disease with the domicile of the patients

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	231.823	3	77.274	18.325	.000
Within Groups	261.450	62	4.217		
Total	493.273	65			

The F-value of 18.325 and the significance level of p=0.000 indicate that at least one group differs significantly from the others in terms of the average number of reported cases. The variability between groups (Sum of Squares = 231.823) accounts for a significant portion of the differences, while the within-group variability (Sum of Squares = 261.450) reflects individual variations within each group.

These results suggest that the observed differences are not random and confirm the existence of distinct reporting patterns among the groups. It is evident from the context that AI and senior specialists tend to report more cases, while specialists and general dentists have reported fewer cases.

DISCUSSION

The findings of this study highlight significant differences in the detection of carious lesions among the different participant groups, namely senior specialists, specialists, general dentists, and AI-assisted diagnosis.

Senior specialists and AI reported the highest number of detected carious lesions, suggesting that experience and technological support play a crucial role in caries detection. AI's ability to consistently identify carious lesions with high accuracy can be attributed to its advanced image processing algorithms and pattern recognition capabilities, which minimize the risk of oversight commonly encountered in human evaluations.

General dentists and specialists reported a lower number of detected lesions, potentially due to differences in diagnostic approach, reliance on clinical examination, and familiarity with radiographic analysis. The statistical analysis revealed a significant difference between these groups, emphasizing the variability in diagnostic accuracy based on professional experience and specialization.

The AI system exhibited a high level of consistency, with a relatively low standard deviation in the number of detected caries. This suggests that AI offers a standardized approach to diagnosis, reducing inter-observer variability that can arise in human assessments. Furthermore, AI's ability to detect caries in their incipient stages allows for earlier intervention, potentially improving long-term oral health outcomes and reducing the need for extensive treatments.

Consistent with our findings, recent research has thoroughly investigated the use of artificial intelligence (AI) for the identification and diagnosis of dental cavities. Khanagar *et al*. (15) conducted a comprehensive evaluation of artificial intelligence (AI) models developed for the purpose of detecting, diagnosing, and predicting dental caries. Researchers found that by incorporating these models into clinical practice, diagnostic accuracy and patient outcomes might be significantly improved.

Also, Al-Khalifa *et al*. (16) reviewed the literature on dental caries and found that AI might be a useful tool for detecting the condition early and accurately. Deep learning models, such as convolutional neural networks (CNNs), can interpret several imaging modalities to aid in the identification and diagnosis of dental caries more efficiently and accurately than conventional approaches, according to the reviewed research.

Furthermore, Frenkel *et al*. (17) conducted an external validation of an AI-based model for caries detection using dental photographs. The study demonstrated that the AI model could detect, classify, localize, and segment carious lesions with high diagnostic accuracy, indicating its potential utility in clinical settings

Despite the promising performance of AI in cavities detection, certain challenges persist. The reliance on high-quality radiographic images is essential for optimal AI performance, and variations in image quality may impact detection accuracy (18). Additionally, AI algorithms are limited by the data they are trained on, which may introduce bias if the training dataset lacks diversity (19).

The integration of AI into routine dental practice offers numerous benefits, including enhanced diagnostic accuracy, improved workflow efficiency, and better patient communication through visual representation of detected lesions (20, 21).

These studies align with our findings, underscoring the significant advantages of AI-assisted diagnostic tools in dental imaging, particularly in the detection of carious lesions. The integration of AI into dental practice offers the potential for earlier intervention, improved diagnostic accuracy, and enhanced patient outcomes.

However, AI should be viewed as a complementary tool rather than a replacement

for clinical judgment, with final treatment decisions remaining under the purview of dental professionals

CONCLUSIONS

The study underscores the potential of AI-assisted diagnosis in enhancing the detection of carious lesions, particularly in cases that may be challenging for human evaluators. Future research should focus on refining AI algorithms, expanding training datasets, and exploring the integration of AI with other diagnostic modalities to further improve diagnostic accuracy and clinical decision-making.

This study demonstrates the significant advantages of AI-assisted diagnostic tools in dental-periodontal imaging, particularly in the detection of carious lesions. The results highlight AI's potential to support dental professionals in achieving higher diagnostic accuracy, reducing variability, and ensuring earlier intervention for better oral health outcomes.

Despite its strengths, AI should be integrated into dental practices with caution, ensuring that it complements rather than replaces the clinical expertise of dental practitioners. Further advancements in AI technology, along with continued training for professionals, will be essential to fully harness its benefits and address its limitations effectively.

CONFLICTS OF INTEREST AND FUNDING

All the authors declare no funding received and no conflict of interest.

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