Research Article

Correlation between dental radiology knowledge and the ability to interpret panoramic radiographs among dental students: Study cross-sectional

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ABSTRACT

Introduction: Knowledge is the result of human curiosity, and in dental education, students are required to understand the fundamentals of dental radiology. Panoramic radiography, as one of the most frequently used imaging modalities, plays an important role in supporting diagnosis; however, limited understanding of basic dental radiology concepts can complicate the interpretation process. This study aimed to analyze the correlation between the level of dental radiology knowledge and the ability to interpret panoramic radiographs among preclinical dental students. **Methods:** This study employed a cross-sectional design using a questionnaire. A total sampling technique was applied, involving 146 students from the Faculty of Dentistry, Universitas Mulawarman. Bivariate analysis was conducted using Spearman's rho correlation test. The variables assessed were dental radiology knowledge and panoramic radiograph interpretation ability. **Results:** The findings indicated that 49.3% of students had good dental radiology knowledge, 41.8% had good ability to interpret panoramic radiographs, and 39.0% were good in both variables. Correlation analysis showed a statistically significant correlation between dental radiology knowledge and the interpretation of panoramic radiographs (Sig. [2-tailed] = 0.001). **Conclusions:** There is a significant correlation between dental radiology knowledge and the ability to interpret panoramic radiographs among dental students at Universitas Mulawarman.

KEYWORDS: knowledge, dental radiology, interpretation, panoramic radiograph, students

Korelasi pengetahuan dental radiologi dengan kemampuan interpretasi radiograf panoramik pada mahasiswa kedokteran gigi: Studi cross-sectional

ABSTRAK

Pendahuluan: *Pengetahuan merupakan hasil dari rasa ingin tahu manusia dan dalam pendidikan kedokteran gigi mahasiswa diharuskan memahami dasar dental radiologi. Radiograf panoramik sebagai modalitas yang sering digunakan memiliki peran penting dalam menunjang diagnosis, namun keterbatasan pemahaman konsep dasar dental radiologi sering menyulitkan proses interpretasinya. Penelitian ini bertujuan untuk menganalisis korelasi antara tingkat pengetahuan dental radiologi dengan kemampuan interpretasi radiograf panoramik pada mahasiswa pra-klinik kedokteran gigi.* **Metode:** *Penelitian ini menggunakan desain cross-sectional dengan menggunakan kuesioner. Penelitian menggunakan teknik total sampling dengan jumlah 146 mahasiswa Fakultas Kedokteran Gigi Universitas Mulawarman. Analisis bivariat menggunakan uji korelasi spearman'rho. Variabel yang diamati adalah pengetahuan dental radiologi dan interpretasi radiograf panoramik.* **Hasil:** *Pengetahuan dental radiologi mahasiswa sebesar 49,3% baik, 41,8% baik dalam menginterpretasi radiograf panoramik, dan 39,0% baik pada keduanya. Uji korelasi antara tingkat pengetahuan dental radiologi dan interpretasi radiograf panoramik menghasilkan nilai Sig. (2-tailed) sebesar 0.001.* **Simpulan:** *Mayoritas mahasiswa memiliki pengetahuan dental radiologi dan interpretasi radiograf panoramik yang baik serta terdapat korelasi antara tingkat pengetahuan dental radiologi dengan interpretasi radiograf panoramik pada mahasiswa.*

KATA KUNCI: *pengetahuan, dental radiologi, interpretasi, radiograf panoramik, mahasiswa*

INTRODUCTION

Knowledge is the result of cognitive construction developed through a systematic process and serves as a foundation for application in real-world contexts.[1] In dental education, mastery of knowledge supports the development of clinical skills.[2] The dental curriculum emphasizes understanding of basic sciences, such as dental radiology, as a foundation for diagnosis and treatment planning.[3]

The increasing complexity of cases and advancements in imaging technology demand a stronger mastery of radiological knowledge.[4] These developments further underscore the need for proficiency in dental radiology. Dental radiology plays a crucial role in understanding imaging principles and techniques, assessing anatomy, detecting pathology, and interpreting variations in radiographic density to support the formulation and evaluation of treatment plans.[5]

Panoramic radiography is a widely used imaging modality because it provides comprehensive visualization of the maxillofacial structures in a single exposure.[6] However, its interpretation is challenging due to superimposition, distortion, and magnification, which may reduce visualization accuracy.[7] This increases the risk of misinterpretation, particularly among preclinical students who may not yet be able to consistently differentiate between normal and pathological structures or variations in radiodensity.[8]

Errors in radiographic interpretation represent a significant concern, as they may lead to misdiagnosis, delayed diagnosis, and ultimately affect treatment outcomes.[9] Cognitive biases, limitations in recognizing normal anatomy, and insufficient understanding of imaging principles are common contributing factors.[10,11] Previous studies indicate that students and early-career dentists are more susceptible to blind spots and perceptual errors due to limited experience.[12]

This underscores the importance of evaluating and strengthening foundational theoretical knowledge in dental radiology, including basic radiological principles, understanding of radiopaque and radiolucent appearances, and the ability to recognize normal anatomy as well as dental and supporting tissue abnormalities on panoramic radiographs as a basis for accurate interpretation.

Panoramic radiographic interpretation plays a crucial role in evaluating the dentition and its supporting structures, including the assessment of eruption patterns during different stages of eruption, as well as the condition of surrounding tissues. In Area 1, interpretation of panoramic radiographs includes the identification of tooth absence or agenesis, persistence, impaction, crown and root conditions, alveolar bone, and periapical status.[13,14] However, interpretative ability in this area remains limited, as reflected in the Objective Structured Clinical Examination (OSCE) results of preclinical students at the Faculty of Dentistry, Mulawarman University, where the pass rates for the panoramic radiography station were low—3.3% for the 2022 cohort and 35.5% for the 2023 cohort.

Arifin *et al*.[6] reported that the majority of early-career dentists demonstrate a moderate level of knowledge, with a proportion still falling into the low category in panoramic radiograph interpretation. This condition indicates challenges in mastering the fundamentals of dental radiology and panoramic radiographic interpretation skills from the preclinical stage, which may persist into the clinical phase. Various studies have proposed efforts to improve radiographic interpretation skills through interactive modules, case-based learning, and the integration of artificial intelligence.[15-17]

Most studies focus on interpretative skills without assessing the relationship between foundational theoretical knowledge in dental radiology and the fundamental competencies required for panoramic radiographic interpretation, particularly among preclinical students who have only recently been introduced to basic dental radiology. In addition, there is still a limited number of studies that specifically evaluate the competencies of this group in Indonesia, even though the preclinical stage represents a critical phase in the development of diagnostic competence.[18]

Based on the identified research gap and its urgency, this study proposes to examine the correlation between the level of dental radiology knowledge and the ability to interpret panoramic radiographs. The novelty of this study lies in its evaluation of the integration between theoretical cognitive aspects and specific interpretative skills in Area 1 of panoramic radiographs, which remains limited in the Indonesian literature, using preclinical students as the study population.

Both variables are essential, as mastery of theoretical knowledge and fundamental interpretative skills form the foundation for the development of clinical diagnostic competence. Therefore, this study aims to analyze the correlation between basic dental radiology knowledge and the ability to interpret panoramic radiographs in Area 1 among preclinical students.

METHODS

This study employed a cross-sectional design to examine the relationship between dental radiology knowledge and panoramic radiographic interpretation ability among preclinical dental students at Mulawarman University. The variables were dental radiology knowledge and panoramic radiographic interpretation ability. The data used were primary data collected through a self-administered questionnaire distributed via Google Forms in September 2025 at the Faculty of Dentistry, Mulawarman University.

The sampling technique applied was total sampling, whereby all eligible students were included as the study sample. The research instrument consisted of two components. The first component was a questionnaire comprising 20 multiple-choice items assessing basic knowledge of dental radiology, including fundamental principles, understanding of radiopaque and radiolucent appearances, and the ability to recognize normal anatomy and pathological conditions of the teeth and their supporting structures. In addition, the second component consisted of seven panoramic radiographic images accompanied by short-answer questions used to assess interpretative ability in Area 1, covering tooth absence or agenesis, persistence, third molar impaction, crown condition, root condition, alveolar bone status, and periapical lesions.

The questionnaire and panoramic radiographs were adapted from the textbook Essentials of Dental Radiography and Radiology by Whaites and Drage et al.,[7] and were validated by experts in dental radiology. The instrument was pilot-tested prior to data collection, and the allotted time for completion was 45 minutes.

Instrument validity was assessed using the Pearson correlation test, while reliability was assessed using Cronbach's alpha. The validity test results (Tables 1 and 2) showed that all items had r-values greater than the r-table value (0.162), indicating that all instruments were valid. Furthermore, the reliability test results (Table 3) demonstrated Cronbach's alpha values above 0.6, indicating that the questionnaire was reliable.

Table 1. Results of the validity test for the dental radiology knowledge instrument

Item	r-value	r-table	Description
Item1	0.425	0.162	Valid
Item2	0.512	0.162	Valid
Item3	0.240	0.162	Valid
Item4	0.333	0.162	Valid
Item5	0.172	0.162	Valid
Item6	0.472	0.162	Valid
Item7	0.475	0.162	Valid
Item8	0.480	0.162	Valid
Item9	0.690	0.162	Valid
Item10	0.600	0.162	Valid
Item11	0.420	0.162	Valid
Item12	0.479	0.162	Valid
Item13	0.631	0.162	Valid
Item14	0.608	0.162	Valid

Item15	0.711	0.162	Valid
Item16	0.630	0.162	Valid
Item17	0.543	0.162	Valid
Item18	0.262	0.162	Valid
Item19	0.526	0.162	Valid
Item20	0.492	0.162	Valid

Table 1 show, the results of the validity test for the dental radiology knowledge instrument, which consists of 20 items. All items demonstrated r-values higher than the r-table value (0.162), ranging from 0.172 to 0.711. These findings indicate that all items in the dental radiology knowledge instrument are valid and suitable for use in this study.

Table 2. Validity test results of the panoramic radiographic interpretation instrument

Item	r-value	r-table	Description
I1	0.473	0.162	Valid
I2	0.273	0.162	Valid
I3	0.505	0.162	Valid
I4	0.464	0.162	Valid
I5	0.533	0.162	Valid
I6	0.367	0.162	Valid
I7	0.371	0.162	Valid

Table 2 Show, the results of the validity test for the panoramic radiographic interpretation instrument, which consists of 7 items. All items showed r-values exceeding the r-table value (0.162), with values ranging from 0.273 to 0.533. Therefore, all items in the panoramic radiographic interpretation instrument are considered valid for assessing respondents' interpretation ability.

Table 3. Results of the reliability test

Variable	Cronbach's alpha	Description
P1-I7	0.853	Reliable

Table 3 show, the results of the reliability test of the research instrument. The Cronbach's alpha value obtained was 0.853, indicating a high level of internal consistency. Therefore, the instrument is considered reliable for data collection. Panoramic radiographs were presented in digital format and displayed on a digital monitor with a minimum resolution of 1920 × 1080 pixels, in accordance with standardized device specifications.

Brightness and contrast settings were standardized prior to the study and applied uniformly across all participants. Radiographic interpretation was conducted in a controlled lighting environment, with blackout curtains used to minimize visual distractions and light reflections. The interpretation process was performed independently by the students, and assessment calibration was conducted in collaboration with a dental radiology expert using standardized evaluation criteria.

Each correct response was assigned a score of 1, and incorrect responses were scored as 0. The total scores for both dental radiology knowledge and panoramic radiographic interpretation were converted into percentages and categorized into three levels: good (80%–100%), moderate (60%–79%), and poor (<60%). Bivariate analysis was performed to determine the correlation between dental radiology knowledge and panoramic radiographic interpretation ability using Spearman's rho correlation test. Statistical analyses were conducted using Microsoft Excel and IBM SPSS Statistics version 24.

RESULTS

This study involved 146 preclinical dental students, comprising those in the third, fifth, and seventh semesters who had completed dental radiology coursework and met the established inclusion and exclusion criteria. The data consisted of primary data collected through two questionnaires administered simultaneously at the same location, as scheduled for each cohort. These instruments were used to assess the correlation between dental radiology knowledge and panoramic radiographic interpretation ability among preclinical dental students at Mulawarman University. The results indicated that the majority of students demonstrated a good level of dental radiology knowledge.

Similarly, most participants exhibited a good ability in panoramic radiographic interpretation, although a proportion of respondents remained in the moderate and poor categories. Further analysis revealed that both knowledge level and interpretative ability tended to increase with advancing academic level. Spearman's rho correlation test demonstrated a statistically significant and strong correlation between dental radiology knowledge and panoramic radiographic interpretation ability among preclinical dental students at Mulawarman University.

Table 4. Characteristics of the study participants

Characteristic	Frequency (n=146)	Percentage (%)
Gender		
Male	39	26.7
Female	107	73.3
Age		
18	15	10.3
19	46	31.5
20	57	39.0
21	25	17.1
22	3	2.1
Academic Level		
Semester 7	26	17.8
Semester 5	58	39.7
Semester 3	62	42.5

Table 4 shows that the majority of respondents were female, totaling 107 individuals (73.3%). The age distribution was predominantly 20 years, with 57 respondents (39.0%). In terms of academic level, most participants were in the third semester (62 students; 42.5%), followed by the fifth semester (58 students; 39.7%) and the seventh semester (26 students; 17.8%).

Table 5. Knowledge of dental radiology

Knowledge of dental radiology	Frequency (n)	Percentage (%)
Good	72	49.3
Moderate	45	30.8
Poor	29	19.9
Total	146	100.0

Table 5 shows that among 146 students, 49.3% demonstrated a good level of basic dental radiology knowledge, 30.8% were in the moderate category, and 19.9% were in the poor category. Overall, the level of basic dental radiology knowledge was categorized as good.

Table 6. Distribution of respondents' responses on dental radiology

Questionnaires	Answers			
	Correct		Incorrect	
	n	%	n	%
Definition of dental radiology (Item 1)	128	87.7	18	12.3
Types of radiation exposure in dental radiology (Item 2)	90	61.6	56	38.4
Radiation dose in dental radiology (Item 3)	76	52.1	70	47.9
Purpose of dental radiology (Item 4)	138	94.5	8	5.5

Radiopaque and radiolucent appearances in dental radiology (Item 5)	68	46.6	78	53.4
Radiographic features of hypodontia (Item 6)	99	67.8	47	32.2
Radiographic appearance of tooth absence (Item 7)	127	87.0	19	13.0
Radiographic appearance of retained (persistent) primary teeth (Item 8)	99	67.8	47	32.2
Persistence of primary teeth on radiographs (Item 9)	121	82.9	25	17.1
Classification of tooth impaction (Item 10)	120	82.2	28	17.8
Classification of tooth impaction (Item 11)	99	67.8	47	32.2
Pathological conditions of the dental crown (Item 12)	132	90.4	14	9.6
Amalgam restoration in the dental crown (Item 13)	127	87.0	19	13.0
Pathological conditions of the tooth root (Item 14)	116	79.5	30	20.5
Root conditions on radiographs (Item 15)	116	79.5	30	20.5
Normal periodontal anatomy (Item 16)	97	66.4	49	33.6
Normal alveolar bone anatomy (Item 17)	102	69.9	44	30.1
Patterns of alveolar bone loss (Item 18)	46	31.5	100	68.5
Periapical anatomical structures (Item 19)	108	74.0	38	26.0
Periapical abscess (Item 20)	116	79.5	30	20.5

Table 6 shows that the level of basic dental radiology knowledge was generally good, as indicated by the majority of respondents providing correct answers. A high percentage of correct responses was observed in items related to the definition and purpose of dental radiology, as well as anatomical and pathological aspects, such as tooth absence, tooth impaction, crown and root conditions, and periapical lesions. However, the proportion of correct responses declined in items related to the identification of radiopaque and radiolucent appearances, as well as patterns of alveolar bone loss.

Table 7. Dental radiology knowledge according to academic level

Academic level	Knowledge of Dental Radiology						Total		Mean of Percentage Score of Dental Radiology Knowledge(%)
	Good		Moderate		Poor				
	n	%	n	%	n	%	n	%	
Semester 7	21	80.8	5	19.2	0	0.0	26	100.0	82.7
Semester 5	29	50.0	23	39.7	6	10.3	58	100.0	77.4
Semester 3	22	35.5	17	27.4	23	37.1	62	100.0	63.7

Table 7 shows that, across the three academic levels, the "good" category was predominantly observed in seventh-semester students (80.8%), the "moderate" category was most common among fifth-semester students (39.7%), and the "poor" category was predominantly found among third-semester students (37.1%). The highest mean percentage was achieved by seventh-semester students (82.7%), followed by fifth-semester students (77.4%) and third-semester students (63.7%).

Table 8. Distribution of respondents' responses on panoramic radiographic interpretation

Distribution of respondents' responses on panoramic radiographic interpretation	Frequency (n)	Percentage (%)
Good	61	41.8
Moderate	43	29.4
Poor	42	28.8
Total	**146**	**100.0**

Table 8 shows that, among 146 students, the majority demonstrated a good level of panoramic radiographic interpretation, with 41.8% categorized as good, 29.4% as moderate, and 28.8% as poor. Overall, the panoramic radiographic interpretation ability of dental students was categorized as good.

Table 9. Response distribution of panoramic radiographic interpretation items

Questionnaires	Correct		Incorrect	
	n	%	n	%
Tooth absence (I1)	96	65.8	50	34.2
Persistence (I2)	121	82.9	25	17.1
Tooth impaction (I3)	114	78.1	32	21.9
Crown condition (I4)	87	59.6	59	40.4
Root condition (I5)	81	55.5	65	44.5
Alveolar crest and furcation condition (I6)	102	69.9	44	30.1
Periapical condition (I7)	110	75.3	36	24.7

Table 9 shows that, among the study participants, the majority provided correct answers in panoramic radiographic interpretation (Area 1). Most respondents were able to identify abnormalities such as retained primary teeth (persistence), tooth impaction, and periapical lesions with a relatively high proportion of correct responses. However, performance declined in aspects such as crown condition, root condition, tooth absence, and patterns of alveolar bone loss.

Table 10. Panoramic radiographic interpretation results according to academic level

Academic level	Good		Moderate		Poor		Total		Mean Percentage Score (%)
	n	%	n	%	n	%	n	%	
Semester 7	20	76.9	5	19.2	1	3.9	26	100.0	83.0
Semester 5	27	46.6	22	37.9	9	15.5	58	100.0	75.0
Semester 3	14	22.6	16	25.8	32	51.6	62	100.0	60.1

Table 10 shows that, across the three academic levels, the "good" category was predominantly observed among seventh-semester students (76.9%), the "moderate" category was most common among fifth-semester students (37.9%), and the "poor" category was predominantly found among third-semester students (51.6%). The highest mean percentage score was achieved by seventh-semester students (83.0%).

Table 11. Correlation between dental radiology knowledge and panoramic radiographic interpretation

Knowledge of dental radiology	Good		Moderate		Poor		Total		p value	Correlation coefficient (r)
	n	%	n	%	n	%	n	%		
Good	57	39.1	12	8.2	3	2.1	72	49.3		
Moderate	4	2.7	30	20.5	11	7.5	45	30.8	0.001	0.808
Poor	0	0.0	1	0.7	28	19.2	29	19.9		
Total	61	41.8	43	29.4	42	28.8	146	100.0		

Table 11 shows that, based on the Spearman correlation test, the significance value (two-tailed) was 0.001, with a correlation coefficient of 0.808. This indicates a statistically significant positive correlation between dental radiology knowledge and panoramic radiographic interpretation ($p < 0.05$), with a strong correlation strength.

DISCUSSION

Based on the study findings, the majority of dental students at Mulawarman University demonstrated a good level of basic dental radiology knowledge. The predominance of the "good" category suggests that the dental curriculum at Mulawarman University provides an adequate theoretical foundation in dental radiology concepts. Understanding dental radiology is a fundamental competency prior to entering the clinical phase, where radiographs serve as essential tools for diagnosis and treatment planning.[18] The study results indicate that students were able to recognize anatomical structures and various radiographic findings, such as tooth absence or agenesis, impaction, crown condition, and root condition, reflecting a solid macroscopic understanding.

These findings are consistent with Raihan et al.,[19] who reported that students demonstrate relatively good level of knowledge in identifying pathological variations in anatomical structures on radiographs, particularly in the root area, crown condition, and tooth germ, with a relatively high proportion of correct responses. These findings suggest that understanding anatomical structures and pathological variations in radiographs is an essential component that supports students' ability to perform more accurate radiographic interpretation.

This achievement is supported by a structured curriculum that provides a strong conceptual foundation through the study of anatomy, pathology, restorative dentistry, orthodontics, and related disciplines. A better understanding of normal anatomy is associated with significantly higher accuracy in radiographic diagnosis.[20] The structured presentation of learning materials, when integrated with prior knowledge, enhances information retention and visual processing ability, thereby enabling students to identify radiographic features.[21]

The results of this study indicate that the proportion of students with a good level of knowledge was dominant. Although most students demonstrated good knowledge, several aspects showed suboptimal performance, particularly in basic knowledge of radiation physics and biology, differences in radiopaque–radiolucent appearances, and radiation protection concepts. The proportion of correct responses below 60% suggests that practical understanding of technical radiological aspects remains limited.

These findings are consistent with Garg and Kapoor et al.,[22] who reported that although dental students generally demonstrate adequate basic knowledge of radiation physics and protection, some students still fall into the below-average knowledge category. Based on the learning stages within the pre-clinical curriculum, these results may reflect limited experience in radiographic procedures. Conceptual understanding tends to improve with concrete experience; however, such exposure remains limited during the pre-clinical phase, particularly in hands-on radiographic acquisition.[23,24]

Analysis of differences across academic years revealed a pattern of increasing knowledge in line with the progression of study duration. Students in the 7th and 5th semesters demonstrated a higher proportion of good-category performance compared to those in the 3rd semester. These findings support Herwita et al.[25] and Gameraddin et al.,[26] which state that increased curricular exposure and more intensive academic experience contribute to a broader understanding of dental radiology. Thus, variations across academic years indicate that the accumulation of theoretical learning and the extent of material exposure significantly contribute to improving dental radiology knowledge.[27]

The ability to perform basic interpretation of panoramic radiographs showed that the majority of students were in the good category. This finding differs from Arifin et al.,[6] who reported that most clinical students were in the moderate category, and from Herwita et al.,[25] who found that preclinical students were predominantly in the moderate category. These results suggest that the dental radiology curriculum at Universitas Mulawarman facilitates the development of interpretation skills through both theoretical and practical learning. The availability of panoramic radiographs, visual learning aids, and guidance from expert dental radiology instructors contributed to these outcomes.

This finding aligns with theories emphasizing that continuous learning experiences and sustained exposure under expert supervision play a crucial role in shaping students' radiographic interpretation competencies.[28] Students' ability to recognize abnormalities with clearly defined radiographic appearances, such as impaction, persistence, and periapical lesions, indicates that they are capable of applying basic knowledge of anatomy and pathology to interpret radiographic findings.

However, interpretative accuracy decreased for structures with subtle anatomical boundaries, such as the alveolar bone, root structures, and the identification of missing teeth. This variation is consistent with Whaites and Drage et al.,[7] who stated that radiographic interpretation requires repeated visual experience to distinguish differences in density and contrast, which are often subtle.

Furthermore, these findings differ from the report by Maeda et al.,[29] which suggested that dental students tend to more easily interpret hard tissues such as bone. This discrepancy may indicate that the limited experience of pre-clinical students at Universitas Mulawarman affects their ability to recognize more detailed anatomical structures.

Variations in interpretation ability across academic years demonstrated a similar pattern to the knowledge outcomes. Students in the 7th semester exhibited higher levels of accuracy compared to those in the 5th and 3rd semesters. This difference can be explained by greater exposure to learning materials, more extensive case-solving experience, and increased practice in radiographic interpretation, all of which accumulate in senior-level students.

These findings are consistent with Mirza et al.,[30] who reported that advanced-level students demonstrate higher interpretation accuracy. However, they contrast with the findings of İlgüy et al.,[31] who reported that intermediate-level students exhibited better performance. This discrepancy suggests that a longer duration of academic experience does not always correlate linearly with improved radiographic interpretation skills. Interpretation ability is influenced by multiple factors, including the quality of instruction, teaching strategies, and the intensity and frequency of radiographic interpretation practice.

The Spearman's rho correlation test revealed a significance value of 0.001, indicating a p-value below 0.05, which demonstrates a statistically significant correlation between dental radiology knowledge and the ability to interpret panoramic radiographs. The strong positive correlation ($r = 0.808$) indicates that an increase in dental radiology knowledge is followed by an improvement in interpretation ability. Radiographic interpretation is a knowledge-based cognitive process, in which understanding radiographic anatomy and the basic principles of image formation influences the accuracy of assessing both anatomical structures and radiographic abnormalities.[7,32]

These findings are consistent with Arifin et al.,[6] who reported a significant correlation between knowledge and panoramic radiograph interpretation skills. Their study showed that students with a better understanding of theoretical knowledge tend to demonstrate higher interpretation accuracy, with both knowledge and interpretation ability categorized as moderate. In contrast, the present study found that both knowledge and interpretation ability among students were predominantly in the good category. Both studies demonstrate a significant correlation between theoretical knowledge and radiographic interpretation ability, emphasizing that mastery of fundamental concepts is a crucial component in the interpretation process.

The limitations of this study include its cross-sectional design, which does not allow for the assessment of students' skill development over time, and the use of radiographs without clinical simulation. Therefore, future studies are recommended to adopt a longitudinal design and explore the role of innovative learning methods, such as case-based learning and digital radiology simulation, in enhancing students' radiographic interpretation competence.

CONCLUSION

Basic knowledge of dental radiology and fundamental skills in panoramic radiograph interpretation among dental students at Universitas Mulawarman were predominantly categorized as good. A significant correlation was identified between dental radiology knowledge and panoramic radiograph interpretation ability in this population.

The educational implications of this study suggest that dental curricula should strengthen the integration of basic dental radiology theory and systematic radiographic interpretation training from the preclinical stage to support the development of advanced diagnostic competence. From a healthcare perspective, strengthening dental radiology knowledge is expected to improve the accuracy of panoramic radiograph interpretation, thereby supporting more precise diagnosis and treatment planning while minimizing the risk of clinical errors. At a broader level, improving dental students' competence in radiographic interpretation may contribute to safer, more effective, and higher-quality oral healthcare services.

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