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Evaluation of the current applications of artificial intelligence in the analysis of dental panoramic radiographs

Doctoral dissertation

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Streszczenie w języku angielskim

Introduction: Artificial intelligence (AI) has become one of the most promising technologies in modern medicine, including dentistry. It is defined as the ability of machines to perform tasks that typically require human intelligence. AI is increasingly enhancing the fields of diagnostics, treatment, and patient care. The availability of large datasets, advancements in hardware such as high-performance processors, and more advanced algorithms have significantly improved automated analysis. In the field of dentistry, AI is being increasingly used in analyzing radiographs, allowing for the detection of various pathologies, such as dental caries, cysts, or bone fractures. One of the most common diagnostic imaging techniques in dentistry is panoramic radiography. It allows for a simultaneous evaluation of all the teeth, the mandible, the maxilla including maxillary sinuses, hard palate, and temporomandibular joints. In recent years, an increasing number of AI-driven software for analyzing dental radiographs have been introduced for commercial use. Therefore, it is important to evaluate the reliability of such tools available in Poland.

Objectives: The objective of this study was to evaluate the potential of AI in analyzing dental panoramic radiographs, with a particular emphasis on its effectiveness in identifying missing teeth, dental caries, dental fillings, root canal fillings, endodontic lesions, implants, dental and implant abutment crowns, as well as pontic crowns.

Materials and methods: In the first manuscript, an overview of systematic reviews was conducted following the PICOS methodology and the PRIOR Statement guidelines. Relevant literature was retrieved from four databases: PubMed, BASE, ACM, and Google Scholar. In the second manuscript, AI-driven software was employed to perform an automated analysis of 1025 panoramic radiographs. The algorithm assessed each tooth position and determined the presence or absence of the following diagnoses: (1) missing tooth, (2) dental caries, (3) dental filling, (4) root canal filling, (5) endodontic lesion, (6) implant, (7) implant abutment crown, (8) pontic crown, (9) dental abutment crown, (10) sound tooth. This cross-sectional study was conducted in accordance with the STROBE guidelines. Point prevalences and Pearson correlation coefficients were calculated. The diagnostic accuracy studies presented in articles 3 and 4 followed the CLAIM checklist and the STARD standard. Over 600 anonymized radiographs were individually evaluated by two dentists. To assess the AI model, performance

metrics such as sensitivity, specificity, precision, and accuracy were calculated. Receiver Operating Characteristic (ROC) curves were also generated.

Results: The overview of systematic reviews showed that AI algorithms achieve over 90% accuracy in identifying teeth, dental caries, and periodontal bone loss. Machine learning models also exhibit high sensitivity (99,95%) and specificity (92%) in detecting periapical lesions. Additionally, AI algorithms can effectively identify conditions such as osteoporosis and maxillary sinusitis, as well as recognize implant types. In the cross-sectional study, dental caries was the most commonly detected pathology, affecting 99% of patients. More than two-thirds of the study participants had at least one root canal filling, and one in five endodontically treated teeth exhibited a periapical lesion. On average, patients had 15 sound teeth with no signs of previous treatment, primarily located in the lower arch. Prosthetic bridges were used more frequently than implants to replace missing teeth. In diagnostic accuracy studies, all performance metrics were above 90% in detecting missing teeth, root canal fillings, and implant abutment crowns. Identifying periapical lesions was characterized by an average sensitivity of 74.7% and precision of 72%. Notably, the lowest precision (65%) was observed in identifying dental abutment crowns.

Conclusions: AI has significant potential to assist dentists in analyzing panoramic radiographs. Implementing this technology in dental offices can enhance the diagnostic process and minimize errors. Furthermore, AI can serve as a valuable tool in epidemiological studies. The cross-sectional study revealed an unsatisfactory oral health condition in a population of approximately one thousand patients, indicating the need for appropriate therapeutic and preventive measures. Nevertheless, the automatic identification of periapical lesions and dental abutment crowns, as well as the effectiveness of evaluating permanent dentition in the presence of primary teeth, still differs significantly from the results obtained by trained professionals. In these fields, this technology requires further refinement. Consequently, AI should not be perceived as a threat to clinicians, but rather as a valuable tool that supports dentists by providing a second opinion. It is crucial to choose appropriately certified AI-driven software that has been validated through rigorous studies.

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