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Determination of periodontal bone loss in panoramic radiographs through artificial intelligence analysis

KEYWORDS
Periodontal bone loss;
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Periodontitis is a severe gum infection that damages the soft tissues and destroys the bone supporting the teeth. It results from bacteria that accumulate in dental plaque and, if left untreated, can lead to tooth loss. Globally, it is estimated that around 90 % of adults may suffer from some form of periodontal disease, highlighting its significant impact on public health. Full-mouth recording protocols (FRP) are considered the gold standard for evaluating an individual's periodontal condition.[1]

In clinical examinations for diagnosing periodontal disease, factors such as the length, color, inflammation, and bleeding of the attached gingiva are evaluated. The height of the alveolar bone is also measured using a periodontal probe, which can be a time-consuming process requiring cooperation from both dentist and patient. Therefore, radiographs serve as an effective auxiliary tool, helping diagnose periodontal disease, assess its progression, and predict treatment outcomes or recurrence. Panoramic radiographs are particularly useful for measuring periodontal bone loss (PBL).[2]

Chung Shan Medical University has developed a detection system using deep convolutional neural networks (CNNs) to identify PBL on panoramic dental radiographs, which has been patented in Taiwan (Patent No. I844494). Panoramic radiographs were employed to evaluate the severity of periodontal disease by analyzing PBL. This was done by measuring the total root length (from the tooth apex to the cementoenamel junction) and the total bone height (from the apex to the marginal bone crest) for each tooth. The periodontal status on full-mouth X-rays is assessed using AI, which categorizes each tooth's PBL as severe (PBL $>$ 2/3), moderate (1/3 $<$ PBL $<$ 2/3), or mild (PBL $<$ 1/3) (Fig. 1).

According to past research data, the accuracy of radiographic-based periodontal bone loss (R-PBL) assessment using high-quality full-mouth X-rays by three examiners with visual identification is 85.7 % (EFP/AAP: European Federation of Periodontology/American Academy of Periodontology).[3] Our system achieved an accuracy of 90.4 % in analyzing 13,809 teeth from 504 panoramic radiographic images.

Periodontal disease not only causes severe damage to the teeth, but research has also found it to be associated with systemic diseases such as endocarditis, diabetes, and dementia to varying degrees.[4] As a result, periodontal disease is under close surveillance and is given significant attention by health departments worldwide. The diagnosis of periodontitis primarily relies on clinical assessment. Although radiographic imaging is less sensitive for assessing the collapse of periodontal tissues, it is now deemed sufficient for establishing the staging of the disease once a periodontitis case has been clinically confirmed.

Therefore, with the application of this AI radiography system, firstly, we can systematically collect and investigate dental public health epidemiology comprehensively or in specific cases, making it easier to understand the periodontal health status of the population. Secondly, in clinical practice, dentists can quickly and easily obtain supplementary diagnoses, while patients can clearly see their periodontal

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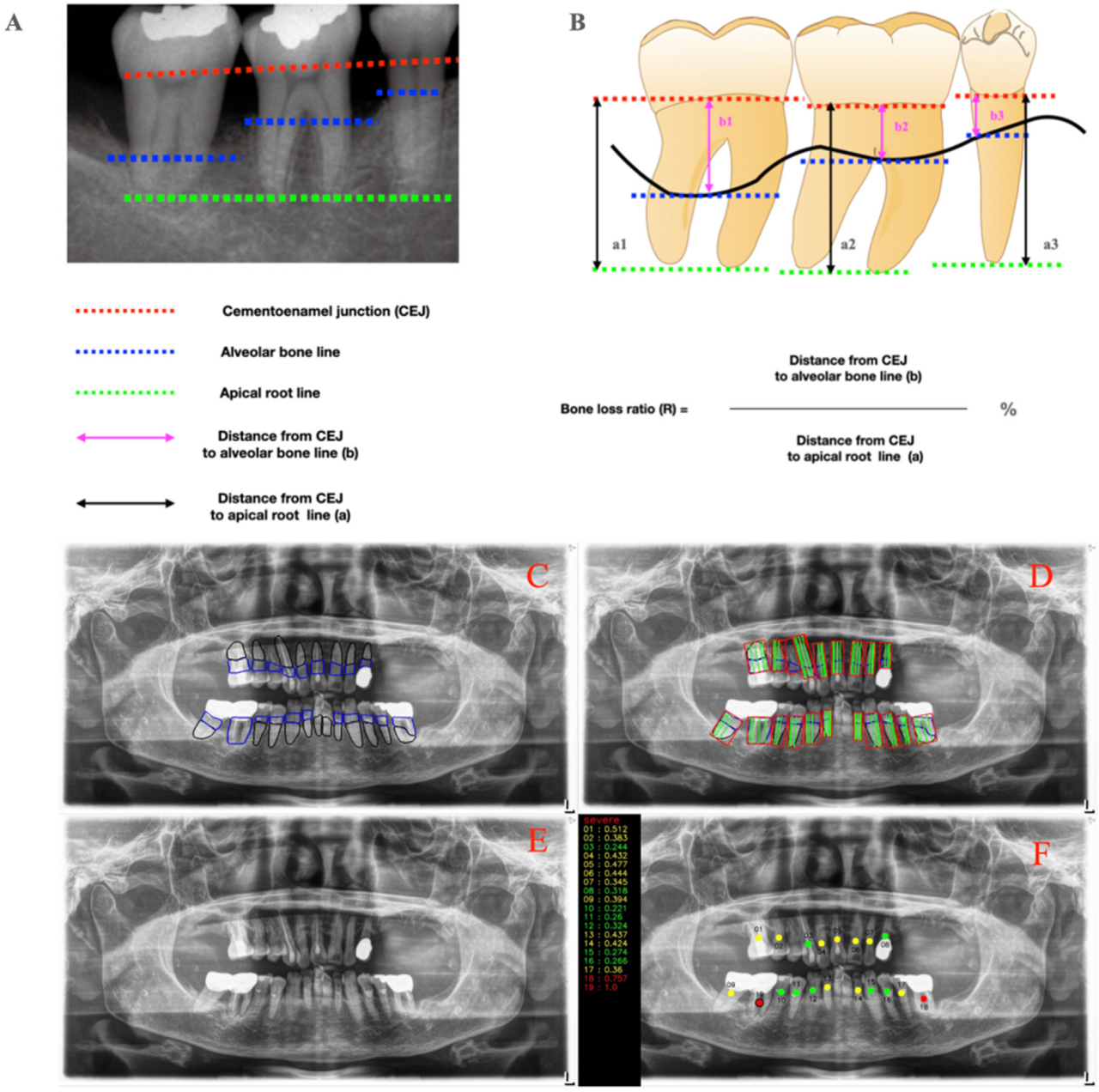

Figure 1 Explanation of periodontal alveolar bone structure and alveolar bone loss. The condition of periodontal alveolar bone loss as analyzed by artificial intelligence in full-mouth radiographs is categorized as follows: mild (PBL ratio less than or equal to 1/3) is represented by a green circle on the X-ray; moderate (PBL ratio greater than 1/3 but less than or equal to 2/3) is shown with a yellow circle; and severe (PBL ratio greater than 2/3 but less than or equal to 1) is depicted with a red circle.
A: It shows that the red dashed line represents the cementoenamel junction, the blue dashed line indicates the alveolar bone, and the green dashed line denotes the position of the apical root.
B: It illustrates the extent of periodontal bone loss (PBL). The calculation method involves dividing the distance from the CEJ of each tooth to its alveolar bone line (pink line b) by the distance from the CEJ of each tooth to its apical root line (black line a).
C: AI searches for the alveolar bone boundary.
D: Marks the cementoenamel junction.
E: Original image.
F: Results obtained after AI analysis, with the left column displaying the PBL ratio (R) values for each type of tooth. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article).

health status at a glance using the AI radiography traffic light indicators (red, yellow, green), thus becoming more attentive to the occurrence of periodontal disease.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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Chia-Tze Kao*
School of Dentistry, Chung Shan Medical University, Taichung, Taiwan
Department of Dentistry, Chung Shan Medical University Hospital, Taichung, Taiwan

Chih-Jen Tseng
School of Medicine, Chung Shan Medical University, Taichung, Taiwan
Department of Obstetrics and Gynecology, Chung Shan Medical University Hospital, Taichung, Taiwan

Ming-Che Tsai
School of Medicine, Chung Shan Medical University, Taichung, Taiwan
Department of Emergency Medicine, Chung Shan Medical University Hospital, Taichung, Taiwan

Chien-Ning Huang
School of Medicine, Chung Shan Medical University, Taichung, Taiwan
Department of Internal Medicine, Chung Shan Medical University Hospital, Taichung, Taiwan

*Corresponding author. School of Dentistry, Chung Shan Medical University, No. 110, Section 1, Chien-Kuo N. Rd., Taichung, 40201, Taiwan.
E-mail address: ctk@csmu.edu.tw (C.-T. Kao)

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