

# Comparison of Fractal Analysis Values Obtained from Panoramic Radiographs with Chatgpt-based Measurements

Elif Töre Sari Can<sup>1\*</sup>, Ayşe Gül Öner Talmaç<sup>2</sup>, Duygu Korkmaz Yalçın<sup>3</sup>

<sup>1</sup>Department of Periodontology, Van Yuzuncu Yıl University, Faculty of Dentistry, Van, Türkiye

<sup>2</sup>Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Kahramanmaraş Sutcu Imam University, Kahramanmaraş, Türkiye

<sup>3</sup>Department of Medical Education and Informatics, Van Yuzuncu Yıl University, Faculty of Medicine, Van, Türkiye

## Abstract

The aim of this study was to evaluate the extent to which fractal dimension values obtained from panoramic radiographs correspond to those obtained manually by an oral and maxillofacial radiologist and to Generative Pre-trained Transformer (GPT) -based fractal analysis (FA) values, and to quantitatively examine the agreement between the two methods.

Panoramic radiographs of 50 patients were examined in the study. Three regions of interest (ROIs) of 15 x 15 pixels were selected from each image. The oral and maxillofacial radiologist measurements were calculated in ImageJ 1.49x, and artificial intelligence measurements were calculated in the ChatGPT-4o environment. Intraclass correlation coefficient (ICC) was used for agreement, Pearson correlation was used for correlation, and Bland–Altman analysis was used for method differences.

The ICC, calculated using a two way mixed model and absolute agreement definition, was found to be negative for both single measurements (ICC(A,1) = -0.06; p = 0.739) and average measurements (ICC(A,2) = -0.134; p = 0.708). The relationship between the measurements was assessed using Pearson correlation analysis. No significant linear relationship was found between the two methods (r = -0.099; p = 0.492).

In its current form, ChatGPT-4o regarding FA does not provide acceptable agreement with radiologist measurements. It is anticipated that artificial intelligence (AI) assisted FA could become a helpful tool in the future with the stabilization of the algorithms/parameters, expansion of the training data, and software validation studies.

**Keywords:** artificial intelligence, fractal analysis, panoramic radiography

## Introduction

Fractal analysis (FA) is a method used to evaluate the complexity of similar structures, including trabecular bone. The results are expressed as the quantitative parameter fractal dimension (FD). Studies have explored the relationships between FD and trabeculation, the porosity of trabecular bone, and bone micro-architecture (1, 2). FA has also been reported to be adequate for diagnosing osteoporotic conditions in the jaws (3, 4). Likewise, FA is increasingly used not only for osteoporotic changes but also for investigating pathologies of the periodontium (5).

Periodontitis is a very common, multifactorial, host mediated inflammatory disease characterized by destruction of the tooth supporting tissues. Being a chronic and progressive condition, its

local manifestations range from bleeding periodontal pockets to tooth loss (6). Although “aggressive periodontitis” was considered a separate category in the 1999 classification, the 2017 World Workshop on the Classification of Periodontal and Periimplant Diseases and Conditions redefined this entity as “periodontitis with rapid progression.” A recent study compared the fractal analysis values obtained from panoramic radiographs of patients with aggressive periodontitis and healthy individuals and reported significant results (7). Based on these findings, it was stated that abnormal trabecular bone patterns may explain some individuals’ susceptibility to rapid, early onset periodontitis, and that FA can detect such changes. It was also emphasized that FA may be valuable for evaluating and diagnosing young individuals with a family history of

\*Corresponding Author: Elif Töre Sari Can, Department of Periodontology, Van Yuzuncu Yıl University, Faculty of Dentistry, Van, Turkey  
E-mail(s): elif\_tore\_sari@hotmail.com, Phone: +90 507 493 88 71

ORCID ID: Elif Töre Sari Can: 0000-0002-3487-0579, Ayşe Gül Öner Talmaç: 0000-0002-0574-5779, Duygu Korkmaz Yalçın: 0000-0003-2969-4934

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aggressive periodontitis (7). This suggests that FA derived from radiographs may help identify at risk individuals particularly during routine check-ups before clinical signs emerge.

In our rapidly advancing digital era, the application of artificial intelligence (AI) in healthcare has increased substantially over the past decade (8). The emergence of AI holds promise for improving health-care outcomes, including reducing costs and expanding access. Its applications span a wide range of areas, such as image-based diagnostics in radiology, ophthalmology, pathology, and dermatology; interpretation of genomic data; clinical prediction; biomarker identification; and robotic surgery, illustrating the breadth of AI use in health services (9). A study investigating whether various AI systems (ChatGPT, model GPT-4.0; Google Gemini; Google Gemini Advanced; and Microsoft Copilot) can be used to reliably access periodontal content reported that ChatGPT-4.0 responses were highly comprehensive with respect to scientific accuracy, clarity, and relevance (10). When combined with AI-based analyses, data obtained from digital imaging may become even more valuable in clinical practice. Therefore, whether image-based methods such as FA can be correctly processed by AI constitutes an important research question. A literature review revealed that there are no studies in dentistry that use AI to perform FA on panoramic radiographs and compare these results to FA results obtained by a oral and maxillofacial radiologist. This study aimed to quantitatively evaluate the agreement between fractal analysis values obtained from panoramic radiographs, manual measurements performed by an oral and maxillofacial radiologist, and measurements obtained by ChatGPT.

## Materials and Methods

This retrospective study was conducted in accordance with the Declaration of Helsinki and was approved by the Non-Interventional Ethics Committee of Yüzüncü Yıl University (2025/01-27). Fifty panoramic radiographic images that met the inclusion criteria were retrospectively collected from the institution's archives. Because the study was designed retrospectively, radiographs from patients who had obtained routine clinical consent forms were used to ensure the anonymity of the data. The patients who were referred to the Van Yüzüncü Yıl University, Faculty of Dentistry, Department of Periodontology, Van, Turkey between March 2025 and May 2025 were included in the study.

Exclusion criteria comprised patients undergoing orthodontic treatment; completely edentulous patients; patients with dental implants; and patients in whom bone reduction had been performed for any reason (e.g., reduction plates present in the jaws following traffic accidents). Inclusion criteria were: patients aged 18–60 years with both the mandibular second premolar and first molar present (to serve as a reference during FA), and high-quality panoramic radiographs in which the periodontal and alveolar bone structures could be clearly delineated. During image selection, standardization was ensured by acquiring all panoramic radiographs with the same device brand (Sirona, Dentsply, Germany). The Sirona panoramic unit operated at 60 kVp, 4 mA, with a scan time of 8 s. Patients' panoramic films were numbered, and from each panoramic film a total of three ROIs measuring  $15 \times 15$  pixels were selected. All ROIs were manually placed by the same experienced periodontist according to a predefined anatomical protocol (mandibular first molar interdental bone, mandibular canine interdental bone, supracortical bone superior to the antegonial notch) (7), and the same pixel coordinates were then used for both ImageJ and the ChatGPT-based pipeline. This approach was designed to minimize variability due to ROI placement. For each patient, the selected ROIs were marked on the panoramic image, and FA measurements were obtained from these marked areas (Figure 1).

**Fractal Analysis Method with ImageJ:** The panoramic radiographs included in the study were imported into ImageJ (U.S. National Institutes of Health, Bethesda, MD, USA) and prepared for fractal analysis (FA). ROIs measuring  $15 \times 15$  pixels were analyzed by an oral and maxillofacial radiologist with 9 years of experience (AGOT) on the same computer (Huawei Matebook 14, 12th Generation Core, China) using ImageJ 1.49x and the box-counting method.

The FA workflow was as follows: the area of interest was cropped, saved in 8-bit format, and duplicated. A Gaussian filter was applied to the duplicate to blur the image, and the blurred image was subtracted from the original. A constant value of 128 was added to each pixel, and a fixed threshold of 128 was set irrespective of the initial brightness. The thresholded image was converted to binary. To reduce noise, morphological erosion and dilation were performed. The image was then inverted and skeletonized so that only the central portions of the trabeculae remained. FA was applied to the skeletonized image using the “box-counting” function in ImageJ (11) (Figure 2).

**ChatGPT-Based Fractal Analysis Method:** All digital image-processing and FA steps were performed in a ChatGPT-4o based, AI-assisted

analysis environment. FA was implemented on a Python 3.8+ platform using the OpenCV, NumPy, SciPy, scikit-image, and Matplotlib libraries. The workflow was as follows:

Panoramic radiographs were first resampled with nearest neighbor interpolation using OpenCV to a resolution of  $2440 \times 1292$  pixels and then converted to grayscale. The predefined ROI coordinates were marked on this standardized image size. Pre-processing included applying a Gaussian blur to reduce noise, followed by subtraction to enhance low-intensity regions. Otsu's thresholding was then used to convert the image to binary, after which one iteration each of erosion and dilation was applied using a  $3 \times 3$  kernel. The image was inverted, and skeletonization was performed to highlight the trabecular structures. FA was conducted with the box-counting method; box sizes were set as powers of two (2, 4, 8, 16, etc.), and the fractal dimension (FD) was computed from the slope of the regression line on the log-log plot.

**Statistical Analysis:** For each subject, three measurements were obtained by both the radiologist and the GPT model. The mean of these three measurements was used for agreement analysis (Bland-Altman and ICC) to avoid inflating reliability estimates due to within-rater repetition. To assess agreement between measurements (ImageJ-ChatGPT-4o), the ICC was used. In addition, the Pearson correlation coefficient was calculated to examine the linear relationship between measurements. Bland-Altman analysis was performed to visualize systematic differences between the two methods and agreement between individual measurements. The level of significance was set at 0.05 for all analyses. Statistical procedures were conducted in SPSS, and the ICC analysis was performed using R.

## Results

In a total of 50 panoramic radiographs, three measurements were obtained for each case by both the radiologist and the ChatGPT-4o model. Descriptive statistics for the differences between oral and maxillofacial radiologist and ChatGPT-4o are shown in Table 1.

The ICC, calculated using a two-way mixed model and absolute agreement definition, was found to be negative for both individual measurements ( $ICC(A,1) = -0.06$ ;  $p = 0.739$ ) and average measurements ( $ICC(A,2) = -0.134$ ;  $p = 0.708$ ) (Table 2). These results indicate that there is no significant agreement between GPT and radiologist measurements.

Additionally, the relationship between the ChatGPT and radiologist measurements was evaluated using Pearson correlation analysis. No significant linear association was observed between the two methods ( $r = -0.099$ ;  $p = 0.492$ ).

The Bland-Altman plot showed a mean bias of 0.13 (SD = 0.18) between the GPT and radiologist measurements (Figure 3). The 95% limits of agreement ranged from  $-0.21$  to  $+0.47$ , indicating that 95% of the differences fell within this interval. The small positive bias suggests that GPT slightly overestimated the measurements compared to the radiologist.

In summary, although the Bland-Altman analysis indicated a small positive bias (0.13), the wide limits of agreement suggest substantial inconsistency between the measurements.

## Discussion

Three ROIs were selected from the panoramic films; across 50 patients, 150 ROIs were analyzed with ImageJ and 150 ROIs with the ChatGPT algorithm, yielding a total of 300 FD values. In the comparison, the FA values obtained with the AI-assisted ChatGPT algorithm were contrasted with the conventional analyses performed by a radiologist in ImageJ. The findings indicated no statistically significant correlation or reliable agreement between the two methods. This result suggests that AI-based analyses do not yet demonstrate accuracy sufficient to replace radiologist assessments, although they indicate potential for future improvement.

FA has recently emerged as a method for evaluating periodontal and alveolar bone morphology (5, 12, 13). In the literature, FD values have been reported to be significantly lower in individuals with periodontitis than in healthy individuals, a finding associated with irregularities in the trabecular architecture (14, 15). FA also stands out as a reliable method for assessing microstructural changes in peri-implant bone tissue (5). These observations support the view that FA can serve as a complementary diagnostic tool in periodontology. However, in the present study, the lack of agreement between radiologist measurements and the application of the same method in an AI environment indicates that methodological challenges remain in automating FA.

Large language models (LLMs) such as ChatGPT have recently been used not only for text generation but also for complex tasks such as code execution and image processing (16). This study is pioneering in showing that ChatGPT can perform FA by leveraging

**Table 1:** Descriptive Statistics Regarding The Differences Between The ChatGPT-Radiologist Fractal Measurement Values

Descriptive Statistics	Value
Sample size	50
Minimum difference	-0.28
Maximum difference	0.55
Mean difference (bias)	0.13
Standard deviation	0.18
95% limit of agreement, lower	-0.21
95% limit of agreement, upper	0.47

**Table 2:** Agreement and Association Analysis Between The Radiologist and ChatGPT Measurements

Measurement type	Model	Agreement type	ICC (95% CI)	F	p-value
Single measures (ICC(A,1))	Two-way mixed	Absolute agreement	-0.0627 (-0.232, 0.145)	0.822	0.739
Average measures (ICC(A,2))	Two-way mixed	Absolute agreement	-0.134 (-0.816, 0.328)	0.822	0.708

“A” indicates absolute agreement. “1” refers to single measures (one rater), and “2” refers to average measures (mean of two raters). ICC(A,1) represents the reliability of a single rater’s measurement, whereas ICC(A,2) represents the agreement between the average measurements of the two raters (radiologist and ChatGPT).

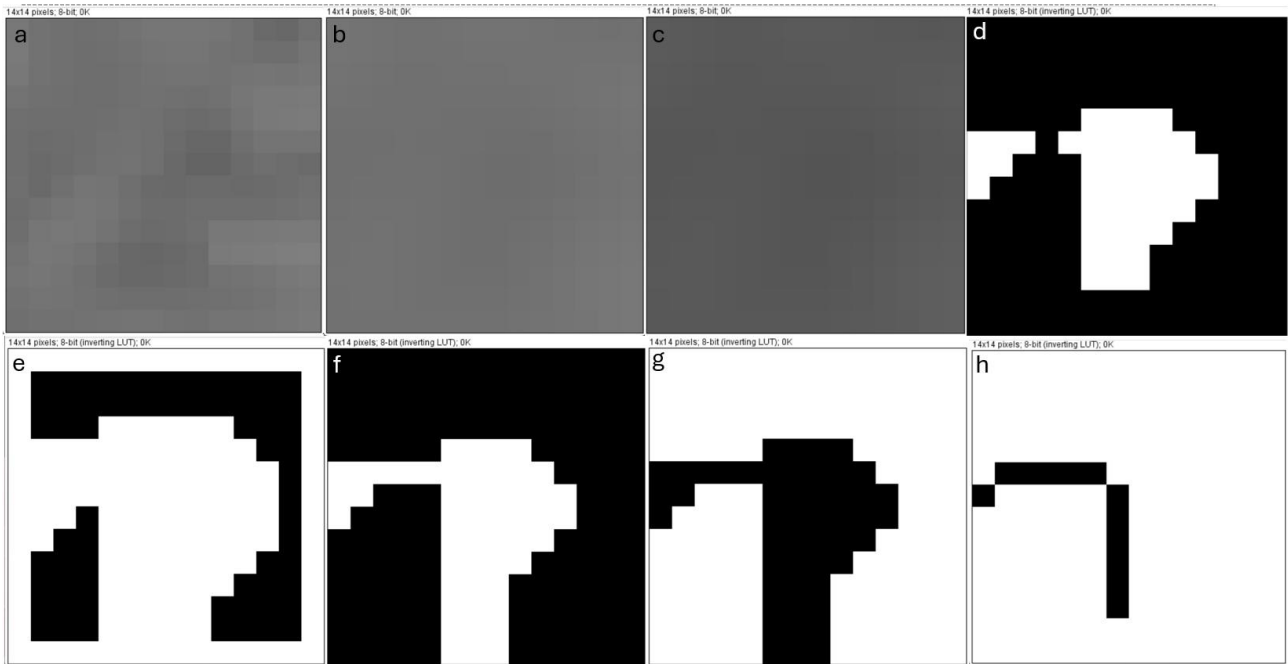


**Fig. 1.** Panoramic radiograph (2440 × 1292 px; 8-bit) showing three 15 × 15 px regions of interest (ROIs) marked in red: interdental bone mesial/distal to the mandibular first molar, interdental bone mesial/distal to the mandibular canine, and supracortical bone superior to the antegonial notch

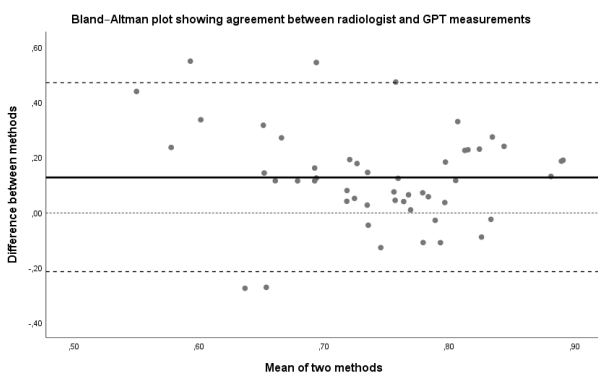
Python-based image-processing libraries (OpenCV, scikit-image, NumPy). Nonetheless, the inconsistency between analyses may stem from the model’s non-deterministic behavior and stochastic variation across runs. Consistent with this, the literature has reported limited reliability of LLM-based models in medical image analysis due to constraints in explainability/interpretability (17).

Additionally, Ullah et al. (18) noted that LLM performance largely depends on the breadth and diversity of the training data, and models not trained with clinical data may exhibit diagnostic bias (18). The fact that a general purpose model like ChatGPT has not been optimized with dentistry or periodontology specific imaging data may be another possible source of the observed measurement differences. The discordance in the results may also stem from differences in measurement approaches and the nature of analysis between the two methods: measurements performed by a radiologist are influenced by human observation and experience, whereas AI-based analysis relies entirely on algorithmic procedures. Consequently, differences in data interpretation, sensitivity to detail, and image pre-processing steps may have introduced variation into the results. Moreover, the small ROI size (15 × 15 pixels) may have restricted the available range of box sizes and increased measurement discrepancies.

This study is one of the studies contributing to the integration of AI into periodontology. While exploring whether FA by enabling a quantitative assessment of bone trabeculation could be considered a potential biomarker for the early diagnosis of periodontal diseases, our findings



**Fig. 2.** Stages of fractal dimension analysis. Duplicated image after cropping (a). Blurred image using a Gaussian filter (sigma, 35) (b). Subtraction process from the original image (c). Binarization (d), erosion (e), dilatation (f), inversion (g), skeletonization (h)



**Fig. 3.** Solid line = mean bias (0.13); Dashed lines = 95% limits of agreement (-0.21, +0.47); Dotted line = reference (Y=0)

indicate that, in its current state, AI-based analyses are not yet directly usable in clinical decision support systems.

Similarly, a study published by Ali et al. (19) emphasized that although AI algorithms may improve the accuracy of radiographic analysis in dentistry, achieving clinical reliability requires optimization of model parameters and diversification of training data (19). The findings of Ali et al. (19) parallel the inferences of the present study and suggest that, when appropriately trained, AI systems can become tools that support radiologists (19).

In this regard, with further algorithm development, parameter stabilization, and expansion of training datasets, AI-assisted fractal value analyses are

anticipated to reach a level that can assist radiologists in the future (19, 20). To the best of our knowledge, this is the first study in the literature to attempt a ChatGPT-based fractal analysis.

This study has several limitations. First, the small ROI areas may have reduced the diversity of box sizes used in the analysis and increased variance in FD values. In addition, the resolution of panoramic radiographs and the effect of overlapping anatomical structures may have hindered the clear separation of trabecular patterns. One limitation of this study is the relatively small number of panoramic radiographs (n=50). Considering these limitations, future studies could achieve more reliable results by combining FA with larger datasets, high resolution cone beam computed tomography data, and AI-based segmentation algorithms. cone-beam computed tomography

In conclusion, although the ChatGPT-4o-based fractal analysis algorithm has not yet achieved a level of reliability sufficient to replace radiologist measurements in its current form, artificial intelligence is expected to assume an important role in dental practice in the future, given its advantages of speed, standardization, and cost in image-based methods.

In this study, the ChatGPT-based fractal analysis algorithm did not exhibit full agreement with the radiologist's measurements obtained with ImageJ. Repeated analyses on the same dataset also showed a certain degree of within method variation. These

findings indicate that, at present, the AI-based approach is not ready to be used as a standalone, reliable method in clinical practice; nevertheless, they underscore the considerable potential of AI for image-based methods such as fractal analysis. With further refinement of the algorithms, standardization of parameters, and formal software validation, such approaches may become more dependable.

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