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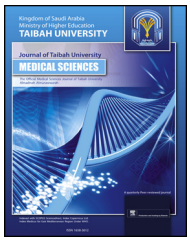

Original Article

# Clinical attachment loss may serve as a more precise, suitable, and pragmatic grading instrument for periodontitis: A clinical and radiographic validation study

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**الملخص**

**أهداف البحث:** تهدف هذه الدراسة الحالية لتقييم حساسية ودقة استخدام فقدان الارتباط السريري كوسيلة بديلة لتصنيف درجة التهاب دواعم السن، مقارنة بنسبة فقدان العظم بين السني المستمدة من الصور الشعاعية ثنائية البعد.

**طرق البحث:** شملت الدراسة الحالية 100 مريض تم تشخيصهم بالتهاب دواعم السن. تم تصنيف التهاب دواعم السن وفقا لتصنيف الجمعية الامريكية لامراض دواعم السن لعام ٢٠١٧. في الجزء الاول من دراسة التحقق هذه، تم حساب نسبة فقدان العظم من الصور الشعاعية حول الذروية والبانورامية ومقارنتها بالتصوير المقطعي المحوسب المخروطي الحزمة. تم قياس فقدان الارتباط السريري وقسمته على طول الجذر لاستخدامه كبديل عن فقدان العظم في تصنيف درجة التهاب دواعم السن. تم تقييم التوافق ونسبة التوافق بين تصنيف فقدان الارتباط السريري والصور الشعاعية حول الذروية والصور البانورامية وتصنيف التصوير المقطعي المحوسب المخروطي الحزمة

**النتائج:** بينت كل من الصور الشعاعية حول الذروية والبانورامية عدم توافق مع تصنيف التصوير المقطعي المحوسب المخروطي الحزمة. في المقابل، بين تصنيف فقدان الارتباط السريري مستوى توافق معتدل (توافق مقبول) مع تصنيف التصوير المقطعي المحوسب المخروطي الحزمة.

**الاستنتاج:** تبدو دقة تقييم فقدان العظم المعتمد على الصور ثنائية البعد لتصنيف درجة التهاب دواعم السن موضع تساؤل. في المقابل، قد يكون قياس فقدان الارتباط السريري لطول الجذر وسيلة دقيقة وسهلة الاستخدام وعملية لتصنيف درجة التهاب دواعم السن. مع ذلك، لا تزال هناك حاجة لدراسات مصممة جيدا لتؤكد النتائج الحالية.

**الكلمات المفتاحية:** فقدان الارتباط السريري؛ التصنيف؛ الدرجة؛ الصور الشعاعية؛ التهاب دواعم السن

**Abstract**

**Objective:** The present study was aimed at assessing the sensitivity and accuracy of using clinical attachment loss (CAL) as a substitute tool for grading periodontitis, instead of the interdental bone loss (BL) percentage derived from two-dimensional radiographs.

**Methods:** One hundred patients diagnosed with periodontitis were included in the study. Periodontitis was graded according to the American Academy of Periodontology (AAP) 2017 classification. In the first part of this validation study, the BL percentage was calculated from periapical and panoramic radiographs and compared with cone beam computed tomography (CBCT). CAL was measured and divided by root length,

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and was subsequently used as a substitute for BL in periodontitis grading. The agreement and percentage agreement among CAL grading, periapical radiographs, panoramic radiographs, and CBCT grading were assessed.

**Results:** Both the periapical and panoramic radiographs showed a lack of agreement with CBCT grading, whereas CAL grading showed a moderately higher level of agreement (fair agreement) with CBCT grading.

**Conclusion:** The accuracy of two-dimensional imaging-based BL assessment for grading periodontitis appears questionable. In contrast, the ratio of CAL to root length might be a more accurate, user-friendly, and practical tool for grading periodontitis. However, further well-designed studies remain necessary to confirm the present results.

**Keywords:** Classification; Clinical attachment loss (CAL); Grade; Periodontitis; Radiograph



## Introduction

Periodontitis is a chronic inflammatory disorder affecting the supporting structures of the teeth, and leading to bone loss(BL), recession, tooth mobility, and eventually tooth loss.[1] Various classification systems have been developed to categorize periodontal diseases. The 1999 classification system divides periodontitis into chronic and aggressive types, according to factors such as the rates of plaque accumulation and bone resorption.[2] Chronic periodontitis is typically associated with high plaque and calculus levels, and a relatively slow rate of BL, whereas aggressive periodontitis is characterized by a faster rate of bone destruction, despite similar levels of plaque accumulation, and has a clearer genetic and immunological background.[2] With research advancements, the distinction between chronic and aggressive periodontitis became less pronounced, thus leading to a unified classification known as periodontitis. In 2017, the American Academy of Periodontology (AAP) introduced a new classification system categorizing periodontitis into four categories according to severity: stages I and II, indicating mild periodontitis; stage III, indicating moderate periodontitis; and stage IV, indicating severe periodontitis.[3] This system also introduced a grading system (grades A, B, and C) to assess disease progression and evaluate the effects of various risk factors.[3] The updated classification system emphasizes comprehensive evaluation of multiple factors, including attachment loss, BL, plaque and calculus accumulation, and the number of teeth lost due to periodontitis.[4]

The recent AAP 2017 classification uses the interdental BL percentage as a tool for grading periodontitis. Traditionally, the severity of BL is assessed according to the ratio of the BL percentage to patient age. This ratio categorizes periodontitis into grades A (<0.25), B (0.25−1), and C (>1).[3] BL is typically measured with two-dimensional radiographs, such as panoramic or periapical radiographs. However, these radiographs can detect bone dissolution only after substantial mineral loss has occurred; consequently, their sensitivity is limited to periodontal defects.[5−7] Clinical attachment loss (CAL) is determined by measuring the distance from the cemento-enamel junction to the base of the periodontal pocket with a periodontal probe.[8] To assess the overall attachment loss of the supporting structures, alveolar BL serves as a reliable indicator.[9]

The correlation of pocket depth and CAL with interdental BL has been the subject of several investigations using panoramic or periapical radiographs.[10] Various correlation findings have been observed, ranging from strong positive correlations to weak positive correlations, particularly in cases involving incipient interdental BL.[10] Clinical observations include instances in which the site with the greatest CAL is not selected for grading according to the AAP classification after radiographic interpretation. Instead, another interdental defect might be chosen according to two-dimensional radiographic findings.[11] However, as described above, two-dimensional radiographs have inherent limitations that undermine their accuracy in assessing BL and thus periodontitis grading. Given these limitations, this study was aimed at assessing the sensitivity and accuracy of using the CAL-to-root-length ratio as an alternative to BL for grading periodontitis. We hypothesized that CAL would be more accurate than BL in grading periodontitis.

## Materials and Methods

### *Study participants and ethical approval*

This study was approved by the Research Ethics Committee of Taibah University (approval No. TUCDREC/011123). The objectives and methods of the study were clearly explained to all participants, and informed consent was provided by each participant. The entire study protocol complied with the applicable guidelines and regulations, including those outlined in the Declaration of Helsinki. This study was organized into three stages to thoroughly address and propose solutions to the limitations of two-dimensional radiographic imaging in dental assessments, particularly concerning the measurement of BL associated with periodontitis. The initial stage examined and substantiated the inherent limitations of two-dimensional radiographic images in accurately quantifying BL. In response to these deficiencies, the second stage introduced a novel method using CAL as a validated metric to increase the precision of BL measurements. Finally, the third stage of the study applied the CAL-based method for grading periodontitis severity while also exploring dental students' perceptions regarding this approach.

A cohort of 100 patients with periodontitis were selected for the study. The inclusion criteria were as follows: systemically healthy individuals with high-resolution panoramic and periapical images, and cone beam computed tomography (CBCT) scans that were clear and free from artifacts that might interfere with the diagnosis of periodontitis. Additionally, only patients who agreed to participate in the study were included. The exclusion criteria were patients with

systemic diseases, or poor-quality or artifact-laden radiographic images, or those unwilling to participate in the study.

The sample size was determined according to a power analysis conducted in the Epi-Info version 2007 software package developed by the World Health Organization and the Centers for Disease Control and Prevention. On the basis of the results of a pilot study in ten cases not included in the current investigation, we determined that the sample size required to detect a 42% difference in accuracy between clinical attachment level (95%) and BL (53%) in the grading of periodontitis, with a significance level of 0.05 and statistical power of 80%, was approximately 100 participants.

*Part 1: Demonstration of the inadequacy of two-dimensional radiographic images in measuring bone loss*

Table 1 presents the site selection for the grading system based on the deepest CAL and radiographically with panoramic radiographs, focusing on BL. The defects with the highest CAL and deepest BL were selected separately. The accuracy of this method was moderate: agreement between CAL and radiographic outcomes was observed in only 43% of cases, thus indicating the model's overall ability to correctly match the two methods. That is, only 43 of every 100 cases were correctly predicted by two-dimensional radiographs.

Given that the outcomes obtained with this approach are ofteninadequate, we sought an alternative method for assessing BL from two-dimensional radiographs. CBCT provides enhanced precision in assessing the BL rate compared to conventional two-dimensional radiographs. Nevertheless, its application is not advised due to the possible detrimental effects on cellular structures. Therefore, we explored CAL as an alternative methodology. CAL operates independently of CBCT while yielding comparable results, indicating its potential utility as a substitute for measuring BL in grading periodontitis, as utilized by AAP classification.

*Part 2: Proposed approach using CAL validation*

To validate our proposed method, we identified the site exhibiting the deepest periodontal defect for each patient, according to CBCT interpretation. This specific defect site was subsequently used for measurements of CAL, and for periapical and panoramic radiographic interpretations. Evaluations were conducted by two experienced periodontists with at least 10 years' clinical experience, to ensure the reliability of the assessments. The initial two analyses were performed 1 week apart by the same periodontist, whereas a third analysis was conducted by an independent periodontist. Intra- and inter-class correlation coefficients were calculated to assess the reliability of the measurements.

We examined the assessment of periodontitis grade by measuring BL on two-dimensional radiographs, according to the AAP classification, or by using our new approach based on CAL. The results of the BL and CAL methods were compared. The BL percentage was determined with CBCT (which is considered the gold standard).

1- The interdental defect with the highest CAL was selected (Figure 1). The calculation of (x), representing the ratio of CAL to root length (obtained from CBCT), was then performed. Subsequently, the grade (Y) was determined according to the modified formula (x/age) and classified as follows:

- Grade A if (Y) was $<0.25$.
- Grade B if (Y) was $0.25-1$.
- Grade C if (Y) was $>1$.

2- The BL percentage (Z) was calculated as BL divided by root length. Subsequently, Z was divided by age. The grading was in accordance with the AAP classification system. This process was performed twice, once with periapical radiographs and again with panoramic radiographs (Figure 2).

Periapical radiographs were acquired with size 2 digital plates (Apixia PSP scanner, USA) through a parallel technique with the film holder (Maquira®, Maringá, Brazil) at a 20 cm focal length. Digital panoramic radiographs were acquired for each patient with a Sirona digital panoramic machine (Sirona dental system GmbH, USA).

3- The same sites selected with CAL were also used to measure the BL percentage (M) at CBCT = BL/root length. Subsequently, M/age was calculated after determination of the grade.

The CBCT scans were acquired with a CS9300 CBCT machine (Carestream Dental, Carestream Health, Inc, USA) at the College of Dentistry, Taibah University, KSA. The exposure parameters were 60 KV, 300 VOXAL, 4 Ma, and 8.01 s.

CBCT was used as the standardization method and reference in this study, because this a diagnostic method has been demonstrated to have 100% sensitivity and specificity (Figure 3).

*Part 3: Application of the proposed CAL method for grading periodontitis: students' perceptions*

To further validate the proposed method, in the third stage of the study, 50 sixth-year dental students (at the Faculty of Dentistry, Taibah University, KSA) were trained on the use of the AAP classification and our proposed CAL method for grading periodontitis. After a comprehensive training program, the students were surveyed regarding their satisfaction and perceptions regarding the applicability of the CAL method to periodontitis grading. The training focused on the correct application of the 2017 AAP classification, particularly in measuring periodontitis severity by using CAL, as outlined in this study. The survey was administered through Google Forms. A brief introduction was provided to elucidate the purpose of the survey. The link to the survey was disseminated to the students. Google Forms automatically analyzed the responses to the survey, which comprised four questions. Students rated their recommendations for CAL on a scale of 1−5, with 1 indicating not recommended and 5 indicating highly recommended. The full questionnaire is provided in Supplementary Table 1.

*Statistical analysis of the data*

After data entry, analysis was conducted in the IBM SPSS software package, version 20.0 (IBM Corp., Armonk, NY). Categorical data are presented as frequencies and percentages. The chi square test was used to examine the relationships among categorical variables. In cases in which more

than 20% of the cells had an expected count below five, Fisher's exact test was used as an alternative approach. The kappa test was used to determine the agreement between the grades obtained from CBCT versus the other methods. The intraclass correlation coefficient was used to assess the reliability of the measurements. The significance of the results was evaluated at the 5% level.

## Results

The intraclass correlation coefficient values for both intra-observer and inter-observer reliability were recorded at 1.0 and 0.98, respectively, across all repeated measures, indicating a high level of reliability.

Grading with CBCT versus other diagnostic methods (periapical, panorama, and CAL) showed varying levels of agreement. Both the periapical and panorama methods showed poor agreement with CBCT, as indicated by low kappa values ($\kappa = 0.080$ and $\kappa = 0.156$, respectively) and non-significant p-values. These findings suggested low consistency between these diagnostic methods. In contrast, the CAL method showed fair agreement ($\kappa = 0.276$) and a significant association ($p = 0.033$) with CBCT, thus indicating higher consistency in grading between these two methods than the other methods. Overall, CBCT showed closer alignment with CAL than the periapical or panorama methods (Table 2). Moreover, the CAL method may be favorable because of its ease of implementation, high precision, and ability to decrease the time and number of measurements necessary to obtain the periodontitis grade.

Fifty undergraduate dental students participated in our survey conducted to determine students' perceptions of our proposed system. The findings revealed that 74% of the students preferred to use CAL for grading, whereas 26% preferred to use the BL percentage.

Further examination of the students' perspectives and rationale for preferring CAL indicated that 40.5% considered CAL to be more accurate, 18.9% found it to be more applicable, 16.2% deemed it to be direct, 13.5% considered it fast, and 10.8% perceived it as easier (Figure 4).

A total of 51.3% of the students chose a rating of 5 (highly recommended), 37.8% chose a rating of 4, and 10.8% chose a rating of 3 for CAL.

**Table 1: Site selection for the grading system according to the deepest CAL and highest bone defect from panoramic radiographs.**

| Case | Site selection according to CAL | Site selection according to radiograph | Case | Site selection according to CAL | Site selection according to radiograph |
|---|---|---|---|---|---|
| Case 1 | 26 | 26 | Case 51 | 11 | 11 |
| Case 2 | 35 | 21 | Case 52 | 12 | 23 |
| Case 3 | 11 | 36 | Case 53 | 26 | 24 |
| Case 4 | 31 | 26 | Case 54 | 21 | 21 |
| Case 5 | 26 | 36 | Case 55 | 32 | 32 |
| Case 6 | 12 | 32 | Case 56 | 44 | 44 |
| Case 7 | 16 | 31 | Case 57 | 16 | 36 |
| Case 8 | 26 | 32 | Case 58 | 36 | 46 |
| Case 9 | 12 | 12 | Case 59 | 36 | 34 |
| Case 10 | 31 | 31 | Case 60 | 46 | 46 |
| Case 11 | 35 | 36 | Case 61 | 47 | 47 |
| Case 12 | 21 | 21 | Case 62 | 47 | 37 |
| Case 13 | 37 | 37 | Case 63 | 42 | 45 |
| Case 14 | 31 | 32 | Case 64 | 32 | 34 |
| Case 15 | 16 | 37 | Case 65 | 16 | 16 |
| Case 16 | 16 | 23 | Case 66 | 16 | 16 |
| Case 17 | 12 | 12 | Case 67 | 27 | 27 |
| Case 18 | 46 | 46 | Case 68 | 11 | 22 |
| Case 19 | 16 | 16 | Case 69 | 36 | 41 |
| Case 20 | 46 | 46 | Case 70 | 37 | 35 |
| Case 21 | 16 | 16 | Case 71 | 31 | 31 |
| Case 22 | 31 | 31 | Case 72 | 16 | 17 |
| Case 23 | 26 | 26 | Case 73 | 45 | 45 |
| Case 24 | 46 | 46 | Case 74 | 24 | 25 |
| Case 25 | 41 | 32 | Case 75 | 26 | 36 |
| Case 26 | 17 | 27 | Case 76 | 25 | 25 |
| Case 27 | 11 | 11 | Case 77 | 27 | 27 |
| Case 28 | 14 | 14 | Case 78 | 11 | 13 |
| Case 29 | 12 | 36 | Case 79 | 22 | 21 |
| Case 30 | 26 | 26 | Case 80 | 17 | 17 |
| Case 31 | 37 | 27 | Case 81 | 15 | 15 |
| Case 32 | 22 | 22 | Case 82 | 16 | 44 |
| Case 33 | 26 | 17 | Case 83 | 27 | 26 |
| Case 34 | 31 | 35 | Case 84 | 26 | 24 |
| Case 35 | 46 | 16 | Case 85 | 35 | 46 |
| Case 36 | 11 | 37 | Case 86 | 36 | 45 |
| Case 37 | 45 | 45 | Case 87 | 27 | 27 |
| Case 38 | 12 | 22 | Case 98 | 43 | 43 |
| Case 39 | 31 | 22 | Case 89 | 33 | 35 |
| Case 40 | 36 | 22 | Case 90 | 11 | 22 |
| Case 41 | 12 | 12 | Case 91 | 42 | 31 |
| Case 42 | 16 | 35 | Case 92 | 11 | 11 |
| Case 43 | 17 | 36 | Case 93 | 36 | 36 |
| Case 44 | 16 | 36 | Case 94 | 45 | 45 |
| Case 45 | 31 | 31 | Case 95 | 36 | 16 |
| Case 46 | 21 | 22 | Case 96 | 37 | 16 |
| Case 47 | 32 | 32 | Case 97 | 24 | 24 |
| Case 48 | 32 | 32 | Case 98 | 13 | 13 |
| Case 49 | 35 | 15 | Case 99 | 11 | 11 |
| Case 50 | 16 | 46 | Case 100 | 12 | 23 |

## Discussion

Any disease classification should facilitate the identification of distinct disease types and accurately categorize variations in the same disease, according to scientifically established characteristics and attributes. As understanding of various diseases and the emergence of new symptoms or traits evolves, existing classifications must be developed and modified[12] to ensure precise and convenient disease identification. Application of this principle to the AAP classification of periodontal diseases has led to development of, and changes to, the classification. Aggressive and chronic periodontitis, which were recognized as separate entities in the 1999 classification, have now been combined and are referred to as periodontitis in the most recent 2017 AAP.[13]

The AAP 2017 classifies periodontitis into four stages according to disease severity (CAL and BL levels). Further examination, including factors such as plaque accumulation rate, tissue breakdown percentage, extracted teeth, BL type, ridge defects, bite collapse, and tooth mobility, can modify

**Figure 1:** Clinical attachment measurement mesial to #13 with a Williams probe.

the stage assignment, thus enhancing diagnosis by addressing previously overlooked aspects. Additionally, a grading system quantifies clinical characteristics and considers disease progression relative to age, thereby categorizing patients into high, moderate, or low-risk groups. This system differentiates between aggressive and chronic periodontitis, and incorporates environmental factors such as smoking and medical history (e.g., diabetes), which affect treatment outcomes and prognosis.[14,15]

Periodontitis grades are identified according to three criteria: direct evidence, indirect evidence, and grade-modifying factors. Direct evidence relies on longitudinal data collected over the past 5 years. Accordingly, periodontitis is classified as grade A if no indication of an increase in CAL is observed during this period. If the increase in CAL is below 2 mm, the periodontitis is categorized as grade B, whereas if the increase is $\geq$ 2 mm, it is classified as grade C. The second method is frequently used when longitudinal data for the past 5 years are unavailable. Grades are determined by dividing the percentage interdental BL observed in two-dimensional X-rays by the patient's age, then assigning the following classifications: grade A for ratios <0.25, grade B for ratios of 0.25−1, and grade C for ratios >1. Smoking and diabetes are considered grade modifiers, because their presence can shift the grade toward a more severe classification.[11]

On the basis of available evidence, significant buccal-lingual dimension involvement must occur before visible hard tissue loss can be detected on conventional (two-dimensional) radiographs. Consequently, the absence of readily discernible BL does not exclude the occurrence of severe primary periodontitis. Therefore, attachment loss, a more frequently assessed parameter, is used instead of BL for the diagnosis of periodontitis. Using BL as the primary criterion would greatly underestimate the detection of periodontitis in early stages and increase the number of false negatives.[16]

The integration of CBCT technology in dentistry has substantially affected radiological diagnosis, probably because of its exceptional 100% sensitivity and specificity. Regardless of the extent of BL, CBCT easily reveals even the slightest changes and enables accurate diagnosis. Additionally, the high resolution and consistent dimensions of the imaged tissues[17] make CBCT the gold standard method; therefore, CBCT served as the reference in this study. Importantly, we are not advocating for the routine use of CBCT as a grading tool for periodontal disease. Instead, we leveraged this advanced imaging modality to enhance understanding of the relationship between CAL and BL in the context of our research. This approach enabled us to validate our concept with an accurate diagnostic tool; however, that further investigation will be necessary to establish standardized grading protocols. Moreover, we specifically selected cases with panoramic images, periapical images, and CBCT scans already available, thus ensuring that no patients were subjected to additional radiation exposure solely for the purpose of this study. The use of these pre-existing images enabled us to conduct our research while prioritizing patient safety and adhering to ethical standards in diagnostic imaging.


**Figure 2:** Interdental BL measurement for distobuccal aspect of the maxillary second molar using a periapical radiograph.

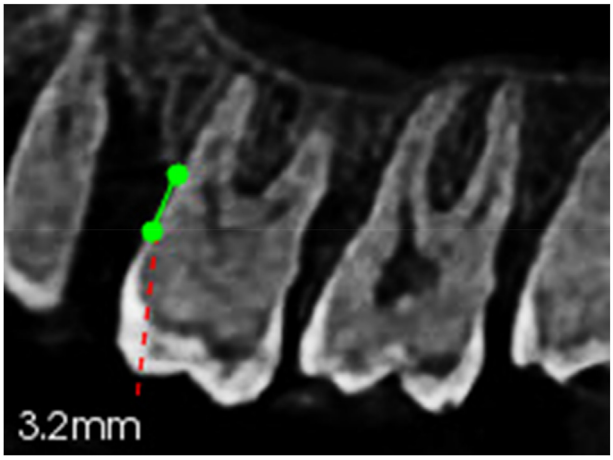


**Figure 3:** Interdental BL measurement for distobuccal aspect of the maxillary second molar using CBCT.

Herein, CAL is proposed as a potential alternative to the interdental BL percentage in two-dimensional radiography, as outlined by the distribution recommended by the AAP in their classification of periodontal disease. Our findings demonstrated moderate concordance in grading based on CAL versus CBCT. In contrast, weak agreement was observed between grading derived from periapical or panoramic radiography versus CBCT grading, whereas CAL had greater accuracy in diagnosis and grading periodontitis.

One notable finding in the present study was the discrepancy between the radiographically selected defect sites for periodontitis grading and the locations exhibiting the highest CAL measurements recorded on the periodontal chart for the same patient. Through statistical analysis, we determined that the agreement between CAL and radiographic outcomes was only 43%. Taking into account the limited sensitivity of two-dimensional radiographs and the fact that CAL is measured from a fixed reference point, the

| Value of κ | Strength of agreement |
|---|---|
| <0.20 | Poor |
| 0.21–0.40 | Fair |
| 0.41–0.60 | Moderate |
| 0.61–0.80 | Good |
| 0.81–1.00 | Very good |

**Table 2: Agreement between grades from CBCT versus periapical and panoramic radiographs, across grades (n = 100).**

| | Grade from CBCT | | $\chi^2$ | p | κ (level of agreement) |
|---|---|---|---|---|---|
| | Grade B (0.25–1.0) | Grade C (>1.0) | | | |
| **Grade from periapical method** | **(n = 35)** | **(n = 65)** | | | |
| Grade B (0.25–1.0) | 16 | 25 | 0.315 | 0.575 | 0.080 (Poor agreement) |
| Grade C (>1.0) | 19 | 40 | | | |
| **Grade from panorama method** | **(n = 35)** | **(n = 65)** | | | |
| Grade B (0.25–1.0) | 21 | 27 | 1.255 | 0.263 | 0.156 (Poor agreement) |
| Grade C (>1.0) | 14 | 38 | | | |
| **Grade from CAL** | **(n = 34)** | **(n = 66)** | | | |
| Grade B (0.25–1.0) | 34 | 45 | 4.973* | $^{FE}$p= | 0.276 (Fair agreement) |
| Grade C (>1.0) | 0 | 21 | | 0.033* | |

χ2: chi square test FE: Fisher's exact test κ: kappa test.
p: p value for relationship between grades from CBCT versus other methods.
*: Statistically significant at $p \leq 0.05$.

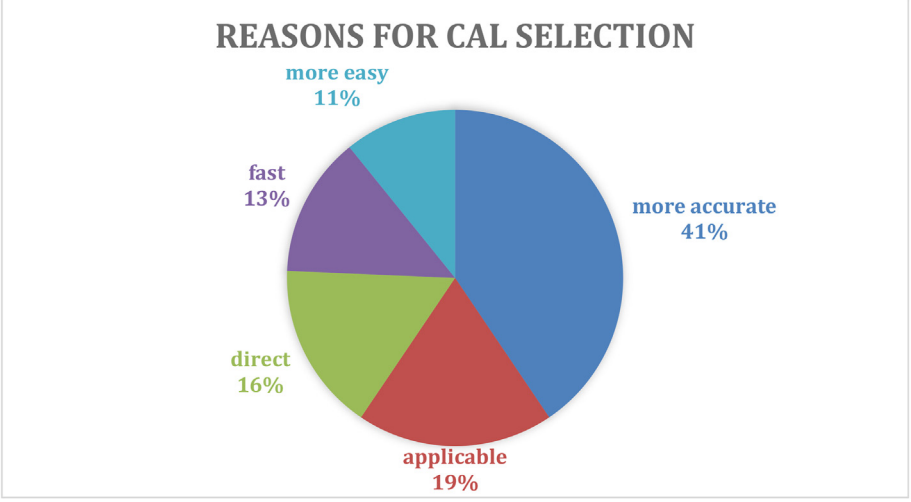


**Figure 4:** Reasons for selection of CAL for grading, according to dental students.

use of CAL is deemed preferable, as it offers a more precise methodology for grading.

To evaluate the applicability of the proposed grading system, we administered an online survey comprising several items on AAP classification with CAL to final-year dental students. Interestingly, the students unanimously favored the use of CAL, because of its superior accuracy, ease of use, applicability, directness, and efficiency. Our examination of students' experiences and understanding provided insights into the method's educational value, usability, and perceived clinical relevance, and highlighted CAL's potential as an effective diagnostic and educational tool for future dental practitioners.

As previously described, the purpose of any classification system is to accurately distinguish among diseases or different forms of the same disease. For the aforementioned reasons, we conducted this study to propose the use of CAL as a more accurate alternative to periodontitis grading.

The findings of this study support CAL as a more reliable and applicable metric for grading periodontitis than BL when two-dimensional radiographs are used. This conclusion is based on the inherent limitations of two-dimensional imaging in accurately representing the intricate three-dimensional structure of alveolar BL.[18] The 2017 AAP classification system for periodontitis recognizes the value of CBCT in comprehensive evaluation of BL. However, in situations in which CBCT is not accessible, CAL might serve as a robust alternative. CAL measures the distance from the cementoenamel junction to the base of the periodontal pocket, thus providing a direct indication of periodontal tissue detachment. This measurement less susceptibility to the distortions and superimpositions that frequently complicate the interpretation of BL in two-dimensional radiographs. Consequently, in the absence of CBCT, CAL might be useful for grading the severity of periodontal diseases, because it is consistent and widely applicable in evaluating periodontal health across various clinical settings. Nevertheless, several study limitations that warrant attention. The primary study limitation is the relatively small sample size, particularly in specific analyses. Another limitation arises from the study's single-center design, which might have compromised the generalizability of the results. Additionally, variability in CAL measurements, influenced by factors such as examiner skills and patient-specific anatomical variations, is another substantial limitation that must be considered. Therefore, further validation studies with larger sample sizes are strongly recommended.

## Conclusions

1. We observed a fair level of agreement between the ratio of CAL to root length and CBCT grading. Although our findings suggest CAL's potential as a substitute for BL in grading periodontitis, additional validation in further studies is necessary to ensure its reliability and accuracy in clinical settings.
2. The CAL grading system is proposed as a potentially more precise and practical approach for grading periodontitis. This system was found to be more user-friendly for clinicians than relying solely on radiographic analysis.
3. The study supports use of the 2017 AAP classification system for periodontitis if CBCT is applied to assess BL. Otherwise, CAL measurements are recommended instead of BL for grading when two-dimensional radiographs are used.
4. The findings of this study have implications for future diagnostic protocols and educational programs, as evidenced by a survey of dental students indicating CAL's applicability and students' satisfaction with learning the CAL-based periodontitis grading system.
5. Because of several inherent methodological limitations, further validation studies are recommended to confirm the present findings.

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## Conflict of interest:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Ethics approval

The research protocol was approved by the Faculty of Dentistry ethics committee at Taibah University, with reference number #TUCDREC/011123.

## Consent

Each patient voluntarily provided written informed consent.

## Authors' contributions

Conceptualization: RMM, MOE, and AYA. Data curation: MOE, AA, and AYA. Formal analysis: MOE, AA, and AYA. Investigation: Rayan M. Meer MOE, and AYA. Software: RMM, MOE, AA, and AYA. Writing—original draft and preparation: RMM, MOE, AA, SAA-M, and AYA. Writing review and editing: RMM, MOE, AA, SAA-M, and AYA. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jtumed.2024.11.009.

## References

1. Highfield J. Diagnosis and classification of periodontal disease. **Aust Dent J 2009**; 54: S11–S26.
2. Graetz C, Mann L, Krois J, Sälzer S, Kahl M, Springer C, Schwendicke F. Comparison of periodontitis patients' classification in the 2018 versus 1999 classification. **J Clin Periodontol 2019**; 46(9): 908–917.
3. Caton JG, Armitage G, Berglundh T, Chapple ILC, Jepsen S, Kornman KS, Mealey BL, Papapanou PN, Sanz M, Tonetti MS. A new classification scheme for periodontal and

peri-implant diseases and conditions—Introduction and key changes from the 1999 classification. **J Clin Periodontol. 2018**; 45 Suppl 20: S1—S8. https://doi.org/10.1111/jcpe.12935.
4. Tonetti MS, Greenwell H, Kornman KS. Staging and grading of periodontitis: framework and proposal of a new classification and case definition. **J Periodontol 2018**; 89: S159—S172.
5. Xu D, Zhao X, Li Y, Ji Y, Zhang J, Wang J, Xie X, Zhou G. The combined effects of X-ray radiation and hindlimb suspension on bone loss. **J Radiat Res 2014**; 55(4): 720—725. https://doi.org/10.1093/jrr/rru014.
6. Berghuis G, Cosyn J, De Bruyn H, Hommez G, Dierens M, Christiaens V. A controlled study on the diagnostic accuracy of panoramic and peri-apical radiography for detecting furcation involvement. **BMC Oral Health 2021**; 21: 1—10.
7. Venkatesh E, Elluru SV. Cone beam computed tomography: basics and applications in dentistry. **J Istanbul Univ Fac Dent 2017**; 51(3 Suppl 1): S102—S121. https://doi.org/10.17096/jiufd.00289.
8. Hughes FJ, Seymour KG, Turner W, Shahdad S, Nohl F. *Clinical problem solving in Periodontology and implantology-E-book*. Elsevier Health Sciences; 2012.
9. Kiliç AR, Efeoglu E, Yilmaz S, Orgun T. The relationship between probing bone loss and standardized radiographic analysis. **Periodontal Clin Investig Off Publ Northeast Soc Periodontists 1998**; 20(1): 25—32.
10. Farook FF, Alodwene H, Alharbi R, Alyami M, Alshahrani A, Almohammadi D, Alnasyan B, Aboelmaaty W. Reliability assessment between clinical attachment loss and alveolar bone level in dental radiographs. **Clin Exp Dent Res 2020**; 6(6): 596—601. https://doi.org/10.1002/cre2.324.
11. Kornman KS, Papapanou PN. Clinical application of the new classification of periodontal diseases: ground rules, clarifications and "gray zones.". **J Periodontol 2020**; 91(3): 352—360.
12. Aggarwal R, Ringold S, Khanna D, Neogi T, Johnson SR, Miller A, Brunner HI, Ogawa R, Felson D, Ogdie A, Aletaha D, Feldman BM. Distinctions between diagnostic and classification criteria? **Arthritis Care Res 2015**; 67(7): 891—897. https://doi.org/10.1002/acr.22583.
13. Babay N, Alshehri F, Al Rowis R. Majors highlights of the new 2017 classification of periodontal and peri-implant diseases and conditions. **Saudi Dent J 2019**; 31(3): 303—305. https://doi.org/10.1016/j.sdentj.2019.04.006.
14. Yildirim BG, Aksit C, Mutlu M, Ainola M, Eklund KK, Leskelä J, Pussinen P, Beklen A. Severity and progression rate of periodontitis are associated with an increased risk of hypertension of patients attending a university clinic. **BMC Oral Health 2022**; 22(1): 627. https://doi.org/10.1186/s12903-022-02637-w.
15. Dentistry AA of P. Classification of periodontal diseases in infants, children, adolescents, and individuals with special health care needs. **Ref Man Pediatr Dent Chicago, Ill Am Acad Pediatr Dent 2021**: 435—449. Published online.
16. Lang NP, Hill RW. Radiographs in periodontitis. **J Clin Periodontol 1977**; 4(1): 16—28.
17. Goodarzi Pour D, Romoozi E, Soleimani Shayesteh Y. Accuracy of cone beam computed tomography for detection of bone loss. **J Dent 2015**; 12(7): 513—523.
18. Christiaens V, De Bruyn H, Thevissen E, Koole S, Dierens M, Cosyn J. Assessment of periodontal bone level revisited: a controlled study on the diagnostic accuracy of clinical evaluation methods and intra-oral radiography. **Clin Oral Invest 2018**; 22: 425—431.

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