A Comparison of Horizontal and Vertical Bitewing Radiographs in Detecting Approximal Caries and Interdental Bone Loss in Posterior Teeth: A Diagnostic Accuracy Randomized Cross-Over Clinical Trial

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1. Background and Rationale

Bitewing radiographs are a standard diagnostic tool in dental practice, primarily used to detect approximal caries and evaluate interproximal alveolar bone levels. Traditionally, horizontal bitewings have been widely used for these purposes. However, they have limitations in visualizing vertical bone loss, furcation involvement, and root caries.

Vertical bitewing radiographs, by contrast, provide greater visibility of the apico-coronal dimension and root structures, making them potentially more effective for diagnosing periodontal conditions and deeper carious lesions. This study aims to compare the diagnostic accuracy of vertical versus horizontal bitewing images in detecting caries and bone loss in posterior teeth.

2. Objectives

Primary Objective

- To compare the accuracy of vertical versus horizontal bitewing radiographs in detecting approximal caries and alveolar bone loss.

Secondary Objective

- To evaluate the effectiveness of both imaging modalities in identifying furcation involvement.
- To assess the diagnostic clarity and patient suitability for each radiographic approach.

Material and methods:

3. Study Design

This is a two-arm, randomized crossover clinical trial comparing vertical and horizontal bitewing radiographs. The study was conducted at the Faculty of Dentistry, King Abdulaziz University.

Type of Study: Open-label, randomized crossover clinical trial

Study Setting: Faculty of Dentistry, King Abdulaziz University

Registration: ClinicalTrials.gov (NCT04341636)

Ethical Approval: KAU Ethics Committee (#053-06-17)

4. Participants

Inclusion Criteria:

- Age ≥18 years
- Presenting for treatment at KAU dental clinics
- Presence of posterior teeth and canines in each quadrant
- No acute periodontal infection
- Non-smokers
- Full ability to open mouth and tolerate X-ray procedures

Exclusion Criteria:

- Systemic conditions complicating treatment
- Pregnancy or lactation
- Prosthesis obscuring CEJ or caries borders
- Gag reflex or any contraindication to X-ray
- Refusal to participate

5. Interventions

Each participant received:

- Four horizontal bitewing radiographs (control)
- Four vertical bitewing radiographs (experimental)
- Radiographs were taken using a standardized film holder and a 3-mm orthodontic wire attached to the sensor for magnification calibration.

Observers included two restorative specialists (for caries) and two periodontists (for bone loss), all blinded to group assignments.

6. Measurements

- Caries Assessment:

  Evaluated using a 5-point diagnostic confidence scale and a secondary clarity scale.

- Bone Loss & Furcation:

  Measured from the CEJ to the alveolar crest using calibrated software. Furcation involvement was assessed using a 5-point scale.

- Intra- and Inter-Observer Agreement:

  Evaluated with Kappa statistics and intra-class correlation coefficients.

7. Sample Size Calculation

- **Software:** G*Power 3.1.9
- Effect size: 2.1 mean difference
- SD: 5.2
- Power: 80%
- Alpha: 0.05
- Required Sample: 20 patients

8. Statistical Analysis

Statistical Analysis

Software:

Data will be analyzed using IBM SPSS Statistics version 23.0 (IBM Corp., Armonk, NY, USA) and ROC analysis will be performed using MedCalc or equivalent software for diagnostic

accuracy assessment.

8.1 Analysis Population:

All radiographs captured for the 20 enrolled participants (160 total bitewing images: 80 vertical, 80 horizontal) will be included. Both intention-to-treat and per-protocol analyses will be conducted. All images were anonymized, and evaluators were blinded to image type and patient identity.

8.2 Primary Analysis:

Primary Endpoints:

- Detection of approximal caries (presence and clarity)
- Alveolar bone level measurements (in mm)
- Presence and clarity of furcation involvement

Tests for Diagnostic Accuracy:

- **Receiver Operating Characteristic (ROC) Analysis**:

  ROC curves were plotted for each evaluator for both vertical and horizontal bitewings. The Area Under the Curve (AUC) was computed to assess diagnostic accuracy compared to the "gold standard" (combined clinical and radiographic diagnosis).

  - AUC values close to 1.0 indicate higher accuracy.
  - Comparisons of AUCs between vertical and horizontal bitewings were conducted using DeLong's test.

- **Sensitivity and Specificity**: These were calculated for each radiographic method in detecting caries and furcation involvement. 95% confidence intervals were provided.

8.3 Observer Reliability:

- **Intra-Observer Agreement**: Measured using **Weighted Kappa coefficients** for repeated readings of the same radiographs by the same observer at two time points.

- **Inter-Observer Agreement**: Measured using **Intraclass Correlation Coefficient (ICC)** for bone level measurements and **Weighted Kappa** for caries and furcation rating scores between observers.

Interpretation of Kappa values:

  - < 0.20: Poor
  - 0.21–0.40: Fair
  - 0.41–0.60: Moderate
  - 0.61–0.80: Substantial
  - 0.81–1.00: Almost perfect

8.4 Comparative Tests Between Vertical and Horizontal Bitewings:

- **Wilcoxon Signed-Rank Test**: Used to compare the mean alveolar bone loss measurements (mesial, distal, and total) between vertical and horizontal bitewings (non-parametric paired comparison).
- **McNemar Test**: Applied to assess paired binary outcomes (e.g., presence vs. absence of caries or furcation involvement) between imaging modalities.
- **Chi-Square Test**: Used to compare proportions of overlapping contacts and furcation detection in both modalities.
- **Descriptive Statistics**:
  - Mean ± standard deviation (SD) for continuous variables (e.g., bone level)
  - Frequencies and percentages for categorical variables (e.g., tooth type, gender distribution)

8.5 Handling of Missing Data:

- Missing image evaluations (if any) were addressed via sensitivity analysis using pairwise deletion, given the minimal expected rate due to controlled data acquisition and blinded

scoring.

8.6 Effect Size Reporting:

- For Wilcoxon and McNemar tests, effect sizes (r) were reported.
- For ROC analysis, 95% CI of AUCs and comparison P-values were provided.

9. Expected Outcomes

- Vertical bitewings will show higher sensitivity in detecting furcation involvement.
- Vertical bitewings will provide better diagnostic accuracy for approximal caries and alveolar bone loss.
- Vertical bitewings will have superior intra- and inter-observer reliability in detecting pathology.

10. Ethical Considerations

- All participants provided informed written consent.
- Ethical approval was secured from local ethics board.
- All data were anonymized and securely stored.
- Participants had the right to withdraw at any time without consequences.

11. Timeline

Phase	**Duration**
Ethical Approval	Completed
Participant Recruitment	2 months
Radiograph Collection	2 months
Data Analysis	1 month

Phase	Duration
Manuscript	1 month

12. Dissemination Plan

The study results will be disseminated through:

- Peer-reviewed publication
- Scientific conferences
- Institutional and ministry health updates

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