Accuracy of extraoral bite-wing radiography in detecting proximal caries and crestal bone loss

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ABSTRACT

Background. Extraoral bite-wing (EB) radiography is an imaging technology used in dentistry. The authors conducted an in vivo study comparing the accuracy of intraoral bitewing (IB) radiographs and EB radiographs for proximal caries and bone loss diagnosis.

Methods. The authors recruited 116 patients who received IB radiographs to receive EB radiographs. The 5 calibrated authors made a consensus radiographic diagnosis of proximal caries and crestal bone loss. For this study, they assumed IB radiographs as the criterion standard. Next, they obtained EB radiographs for the 116 patients and calculated sensitivity, specificity, and false-positive rates against each patient's IB radiograph.

Results. The patients' EB radiographs revealed a significantly greater number of caries and crestal bone loss findings compared with their IB radiographs. The EB radiographs had a high to excellent sensitivity and moderate to low specificity of caries and crestal bone loss findings, respectively. Considering IB radiographs to be the criterion standard, the false-positive rate for EB radiographs was moderate for caries and high for bone loss diagnosis.

Conclusions. The EB radiographs, which generate fewer images of overlapping proximal surfaces, have the advantage of detecting more carious lesions and bone loss findings than the IB radiographs do, but with the disadvantage of more false-positive diagnoses. Further research is needed to evaluate if the false-positive findings represent true carious lesions and bone loss.

Practical Implications. EB radiography is a promising technology, which has several advantages over traditional IB radiography. Clinicians should be aware of false-positive diagnosis of caries and bone loss with EB radiography.

Key Words. Bite-wing radiography; caries; periodontal bone loss.

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Widely used intraoral bite-wing (IB) radiography is less than perfect in diagnosing proximal caries or crestal bone loss. For proximal caries diagnosis, both visual-tactile methods and bite-wing radiography result in a limited sensitivity and a high specificity.[1-3] Traditional bite-wing radiographs are reported to reveal only approximately 60% of proximal carious lesions.[4] Although intraoral radiographs underestimate crestal bone loss,[5,6] bite-wing radiography remains the preferred clinical tool for examination. Other diagnostic tools—for example, fiber-optic transillumination or cone beam computed tomography—provide limited diagnostic information in caries or periodontal disease detection.[7,8]

Using film-based panoramic radiographs, several studies showed low diagnostic utility of panoramic radiographs in detecting proximal caries or crestal bone levels.[9-15] Those studies, therefore, affirmed bite-wing radiography remained the sole radiographic mode of examination for proximal caries and crestal bone diagnosis.

In the last 10 years, some panoramic x-ray units have been developed that generate extraoral bite-wing (EB) radiographs using digital sensors and the robotic motion of a panoramic x-ray tube. Several in vivo and in vitro reports have shown promising results of EB radiography in proximal caries diagnosis.[4,16-19] Marginal bone loss diagnosis using panoramic radiography is comparable to bite-wing radiographs.[15] Using a small sample size of 20 participants, Terry and colleagues[17] showed that proximal caries diagnosis was not significantly different between intraoral and extraoral panoramic bite-wings.

Given these reports on EB radiography, understanding uses and limitations would be important to identifying practical clinical integration. The purpose of this study was to evaluate the diagnostic ability of EB radiography, in contrast to that of IB radiography, for proximal caries and proximal bone loss diagnoses.

METHODS

For this study, we used a radiography program (True Bitewing [Planmeca]) on a panoramic machine (ProMax 2D S3, [Planmeca]), which used a patented technology (SCARA [Selectively Compliant Articulating Robotic Arm]). This technology used a fully programmable 3-axis robot to control the rotation and angles of the radiographic beam aimed perpendicularly with the long axis of the patient's teeth.[17,19] The radiography program generated bilateral EB radiographs with 1 movement of the machine. Each EB radiograph typically captured complete crowns and roots of canines to third molars of both arches. Using this program, our prospective study's specific aims were to compare the diagnostic accuracy of IB and EB radiographs generated by the panoramic unit for proximal caries, and to compare the diagnostic accuracy of IB and EB radiographs generated by the panoramic unit for proximal bone loss.

Participants. The Institutional Review Board of the University of Minnesota approved the study. We screened new patients from the University of Minnesota School of Dentistry in Minneapolis, MN, to identify those who had radiographic evidence of caries or bone loss. We exposed patients' dentitions diagnostically using IB (horizontal or vertical) radiographs (Schick intraoral digital x-ray sensors, Schick AimRight adhesive positioning system, Sirona Dental) before inclusion in the study, as a part of their diagnostic workup. Inclusion criteria for this study was presence of posterior dentition, normal tooth alignment, and contacts between posterior teeth. Exclusion criteria were orthodontic or prosthetic appliances that compromised proximal views of teeth, severe posterior crowding, and pregnancy.

We enrolled participants. Informed consent was obtained. Their dentitions were exposed for EB radiographs (True Bitewing, ProMax S3). Participants were then compensated financially. All identifying information was removed from the resulting digital EB radiographs.

Examiners. Five examiners—2 board-certified oral and maxillofacial radiologists (R.L. and M.A.), 1 general dentist in private practice (D.R.), 1 radiology clinical assistant professor (T.D.), and 1 periodontal resident (M.C.)—reviewed the radiographs. We viewed images on individual 22-inch monitors (Dell) in a dimly lit room. We examined all images using viewing software (Romexis, Planmeca).

Interexaminer calibration. All examiners reviewed 20 vertical IB radiographs, 20 horizontal IB radiographs, and 20 EB radiographs to reach $\geq$ 90% interexaminer reproducibility on identification of proximal caries and proximal bone loss before examining the study participants' radiographs.

Evaluation of the radiographs. We separately evaluated each participant's IB and EB radiographs and generated for each patient's tooth and each proximal surface, a consensus caries and bone loss diagnoses. For the diagnosis of caries, our observations were coded as follows: 0, proximal surface with no caries; 1, caries less than one-half way through the enamel; 2, caries more than one-half way through the enamel but not into dentin; 3, caries into dentin but less than one-half way through the dentin; 4, caries more than one-half way through the dentin; 5, overlapping contacts; 6, missing tooth; 7, surface not seen on image; and 8, defective margin of a restoration. If multiple characteristics were observed (such as overlapping contacts, yet evident carious lesion), we recorded the most critical observation, the presence of caries.

For the diagnosis of bone loss, recorded observations were 0, proximal bone not visible; 1, bone loss evident ($>$ 1.5-millimeter distance from alveolar crest to cementoenamel junction); 2, normal bone level ($\leq$ 1.5-mm distance from alveolar crest to cementoenamel junction); 3, tooth not in image; and 4, missing tooth. If multiple characteristics were observed (for example, normal bone level on the mesial aspect, although bone loss on the distal aspect), we recorded the most critical observation, bone loss. Observations for bone loss were designated for a single tooth, regardless of aspect (mesial or distal) and severity.

Statistical analysis. We used counts and percentages to summarize the caries and bone loss assessments. Using a generalized estimating equations model, we calculated percentage agreement along with a 95% confidence interval for the subset of locations in which caries (or bone loss) could be assessed on both IB and EB images. This model takes into account within-participant correlation. In addition, we calculated sensitivity, specificity, and false-positive rates. We used similar models to compare caries detection (or bone loss) rates between images. We used statistical software (SAS Version 9.3, SAS Institute) for the analyses.

ABBREVIATION KEY. EB: Extraoral bite-wing. **IB:** Intraoral bite-wing.