THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Dental Faculty Practice Radiology Group
(919) 537-3561 Appointments
(919) 537-3160 Radiologists
(919) 966-0705 Fax
www.dentistry.unc.edu

Dr. André Mol | Department of Diagnostic Sciences
School of Dentistry, 5411L Koury Oral Health Sciences
The University of North Carolina at Chapel Hill
Chapel Hill, NC 27599-7455
(919) 537-3142 | Andre_Mol@unc.edu

Comparison of a stationary intraoral tomosynthesis using a carbon nanotube field emission x-ray source and conventional two-dimensional imaging for proximal caries detection. An observer study.

- **Purpose.** To compare stationary intraoral tomosynthesis (s-IOT) with conventional 2D intraoral imaging for caries detection.
- **Imaging protocol.** A bench-top system at UNC was used for s-IOT using two dose levels (low and regular). A standard clinical Instrumentarium Focus x-ray machine in the UNC School of Dentistry was used for 2D imaging. A SuniRay2 CMOS intraoral detector was used for both systems. The s-IOT images were reconstructed using the iterative tomosynthesis reconstruction algorithm. Figure 1 shows representative images of each of the modalities as well as images based on new reconstruction techniques developed after the observer study.
- **Sample.** Unrestored or minimally restored extracted human premolar and molar teeth were selected. Teeth with sound proximal surfaces were included as well as teeth with small to moderate proximal carious lesions as estimated by visual, tactile and bitewing radiographic techniques. Teeth with large, cavitated coronal lesions were excluded. A total of 29 extracted teeth were selected for the study. Three of the 29 teeth were used twice in the sample, giving a total tooth sample of 32 teeth and 64 surfaces.
- **Observations.** Eight experienced oral and maxillofacial radiologists and oral and maxillofacial graduate students reviewed the images from both modalities in random order. Each observer was asked to assess the presence or absence of a carious lesion using a 5-point rating scale: 1 = caries definitely not present; 2 = caries probably not present; 3 = unsure; 4 = caries probably present; 5 = caries definitely present. Receiver Operating Characteristic (ROC) curves were generated to calculate the areas under the curves (AUC) as a measure of overall diagnostic accuracy. Following dichotomization of the response data, sensitivity and specificity values were also calculated. Ground truth was determined using micro-CT imaging of each individual tooth.
- **Results.** Table 1 shows the results of all three measures of diagnostic performance for each of the modalities

Table I. Mean and standard deviation for Receiver Operating Characteristic area under the curve (ROC AUC), sensitivity and specificity for traditional bitewing radiographs (2D), low dose stationary intraoral tomosynthesis (s-IOT$_{low}$) and regular dose stationary intraoral tomosynthesis (s-IOT$_{regular}$).

	ROC AUC	Sensitivity	Specificity
2D	0.77 (0.07)	0.42 (0.11)	0.99 (0.01)
s-IOT$_{low}$	0.77 (0.03)	0.48 (0.09)	0.95 (0.04)
s-IOT$_{regular}$	0.84 (0.04)	0.57 (0.12)	0.97 (0.04)

Analysis of variance showed statistically significant differences between ROC AUC values, with s-IOT$_{regular}$ outperforming 2D and s-IOT$_{low}$. Differences in sensitivity between modalities were statistically significant, with s-IOT$_{regular}$ outperforming 2D and s-IOT$_{low}$. Differences in specificity between modalities were statistically significant, with s-IOT$_{low}$ having a lower specificity than 2D and s-IOT$_{regular}$. Figure 2 shows representative images of tomosynthesis, other 2D modalities, and ground truth micro-CT slices.

- **Conclusions.** The regular dose stationary intraoral tomosynthesis (s-IOT$_{regular}$) showed a 36% increase in sensitivity for caries detection compared to standard bitewing radiographs without a significant decrease in specificity. This result was confirmed by the significant increase in overall diagnostic performance as measured by ROC AUC.
- **Summary:** The results of the observer study show a remarkable increase in sensitivity as compared to previous studies without a sacrifice in specificity. A continued improvement in processing algorithms and fine-tuning of the s-IOT will most likely further improve caries detection sensitivity at both low and regular doses. We are currently preparing a manuscript to be submitted for publication in Oral Surgery Oral Medicine Oral Pathology and Oral Radiology.

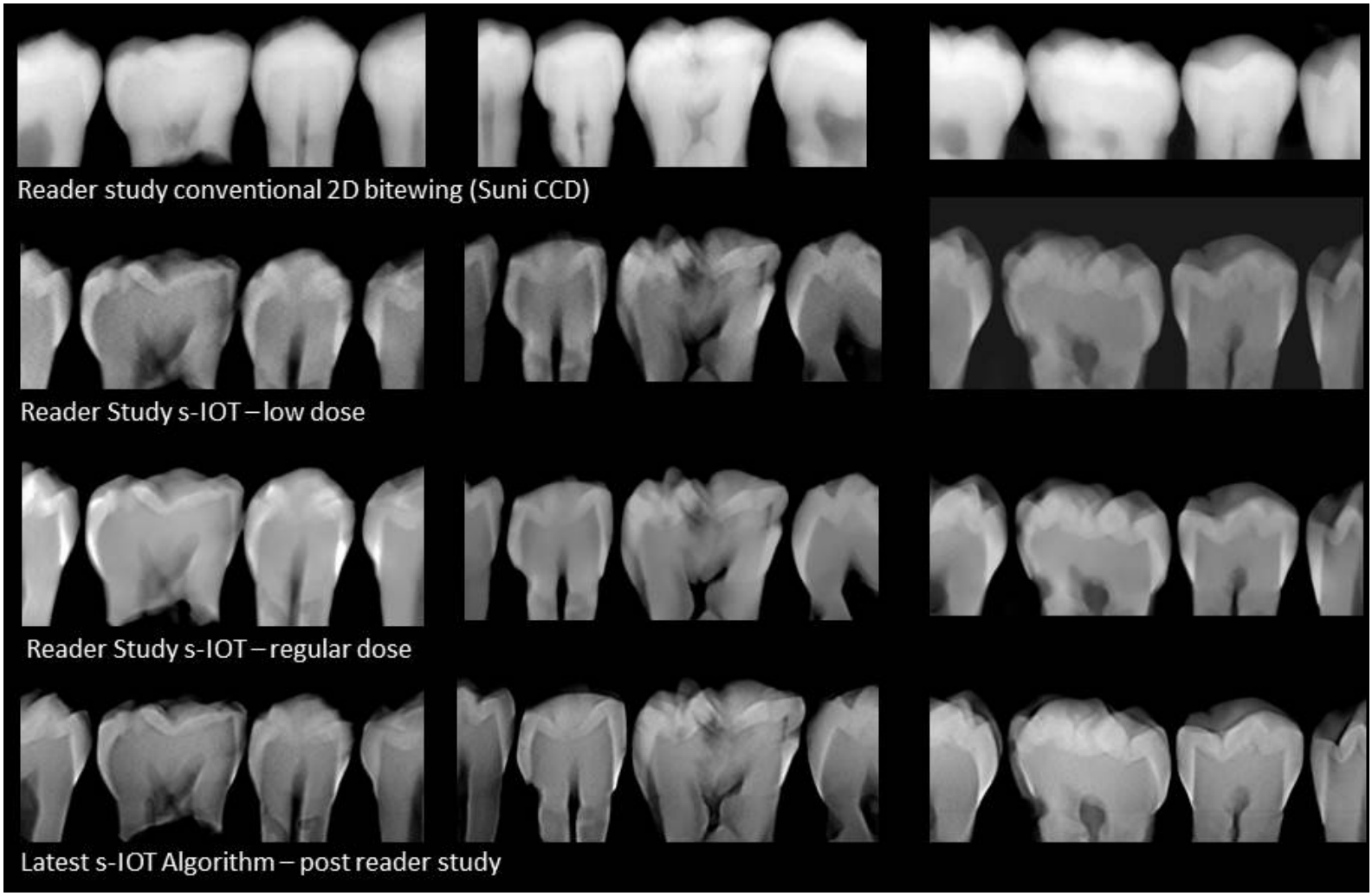
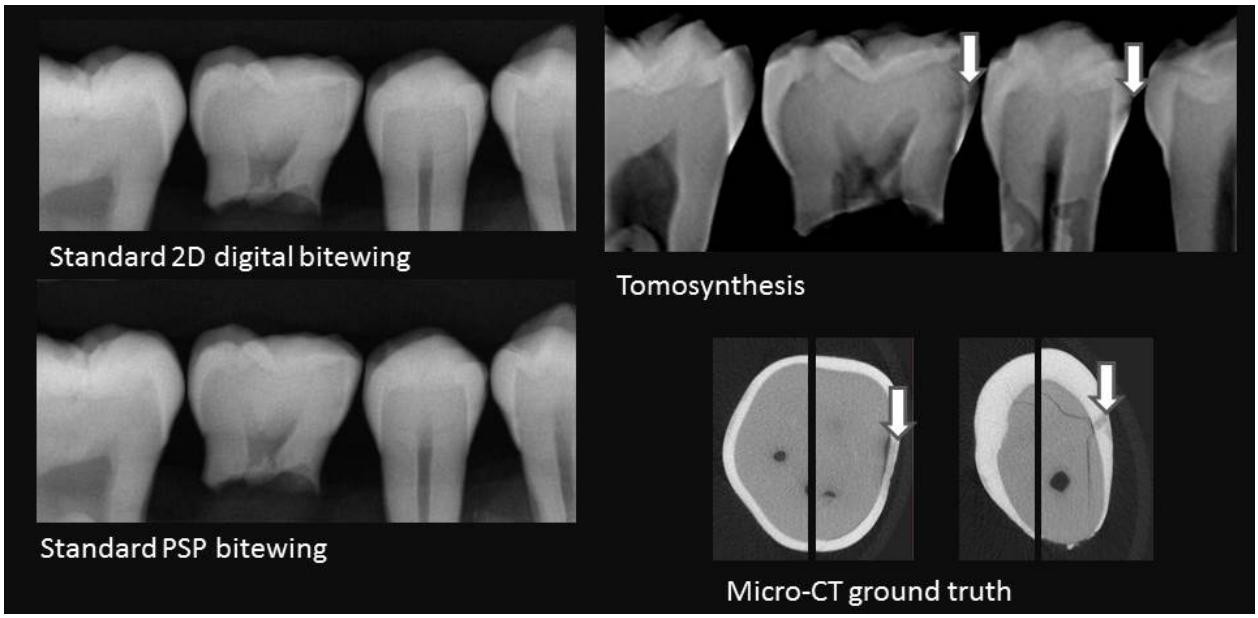
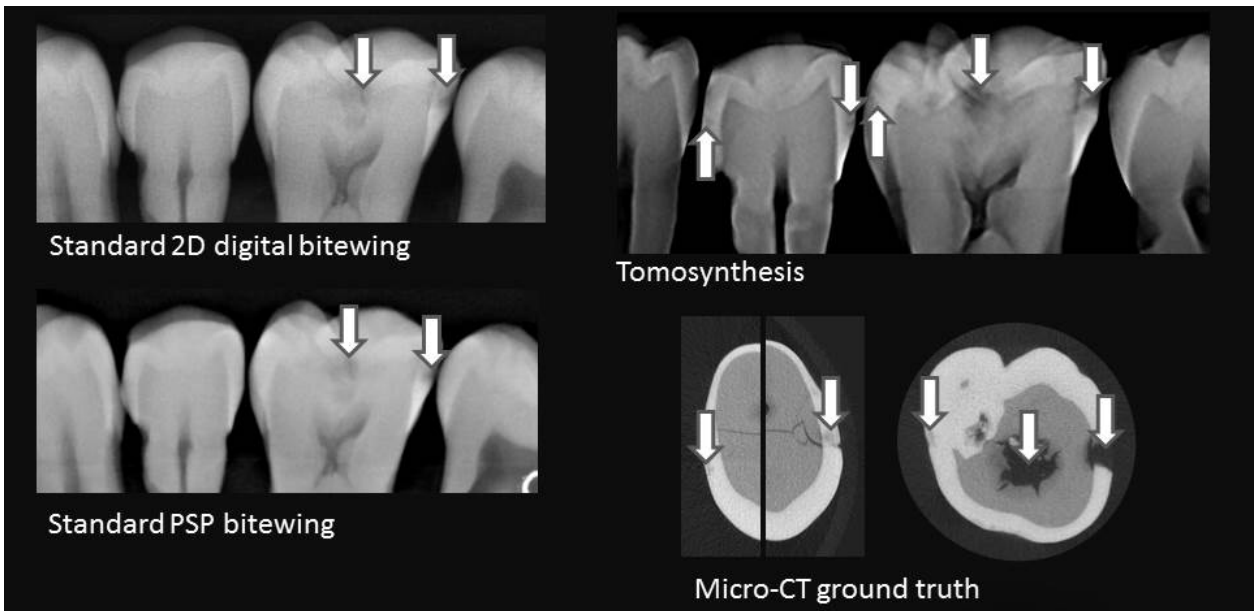


Figure 1: Comparison of 2D bitewing radiographs, s-IOT images at two different dose levels, and the latest reconstruction algorithm s-IOT images (post observer study). Image data for all images 2D and s-IOT was acquired using the same direct digital detector. s-IOT images demonstrate improved definition and contrast of dental anatomy and lesions. Improved s-IOT reconstruction algorithms demonstrate improved image quality, better dose management, and better artifact management.


Standard 2D digital bitewing
Tomosynthesis
Standard PSP bitewing
Micro-CT ground truth


Standard 2D digital bitewing
Tomosynthesis
Standard PSP bitewing
Micro-CT ground truth

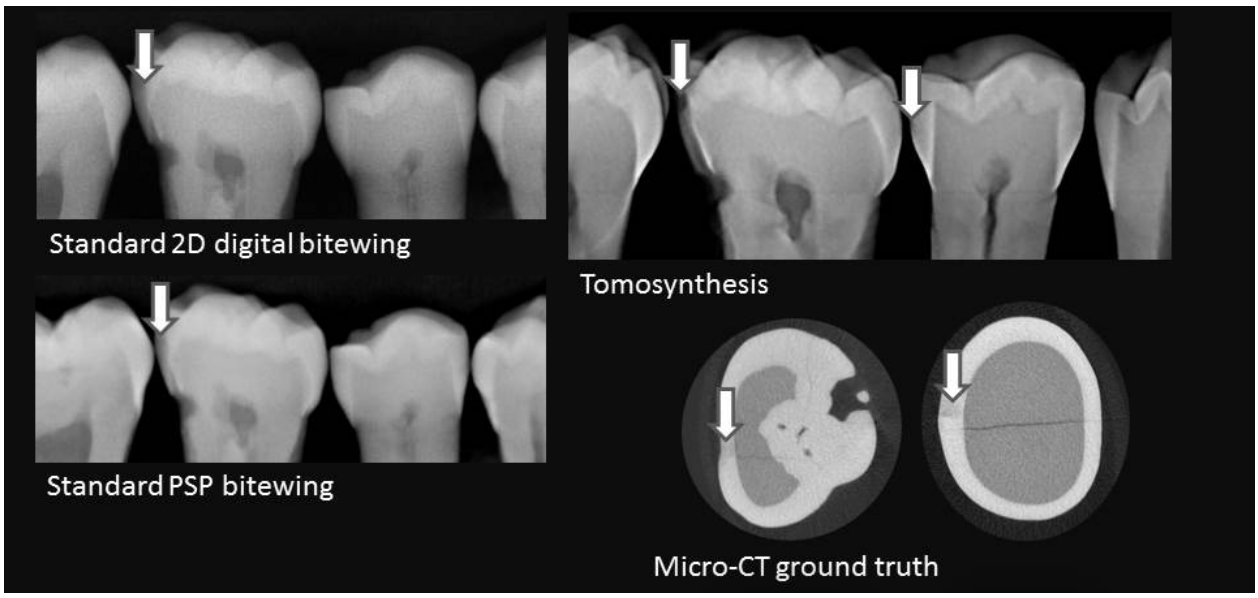

Standard 2D digital bitewing
Tomosynthesis
Standard PSP bitewing
Micro-CT ground truth

Figure 2. Comparison of other 2D intraoral bitewing images with s-IOT using extracted teeth. 2D intraoral images were acquired using either photostimulable phosphor (PSP) or a direct digital sensor. Tomosynthesis images were taken using the proof-of-concept s-IOT system and a digital sensor, and reconstructed using an iterative tomosynthesis reconstruction algorithm. The middle two teeth are the teeth of interest in each image. Micro-CT axial images display ground truth lesion status. Visualization of lesions is improved in the tomosynthesis images. Arrows on the 2D and s-IOT images indicate visible caries lesions. Arrows on the micro-CT images indicate confirmed lesions.

Respectfully submitted,

André Mol
Clinical Associate Professor, Oral and Maxillofacial Radiology

Enrique Platin
Clinical Professor, Oral and Maxillofacial Radiology

Laurence R. Gaalaas
Senior student, Oral and Maxillofacial Radiology Graduate Program