Intraoral Tomosynthesis Using Carbon Nanotube (CNT) X-ray Technology: Primary Caries Detection

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Xintek Nanotechnology Innovations

Background

- The authors recently demonstrated the feasibility of a stationary intraoral tomosynthesis system (s-IOT) using carbon nanotube (CNT) field-emission X-ray technology for dental applications[1]
- The system allows rapid, low-dose, 3D image acquisition without mechanical motion

Objectives

- To compare s-IOT with conventional 2D intraoral imaging for primary proximal caries detection

Materials and Methods

- 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 was used for 2D imaging
- Both systems used a SuniRay2 CMOS intraoral detector
- The s-IOT images were reconstructed using an iterative tomosynthesis reconstruction algorithm (Figures 1 and 2)
- An IRB-approved *ex vivo* study design using 29 extracted human teeth, eight expert observers, ROC analysis, and micro-CT ground truth was employed

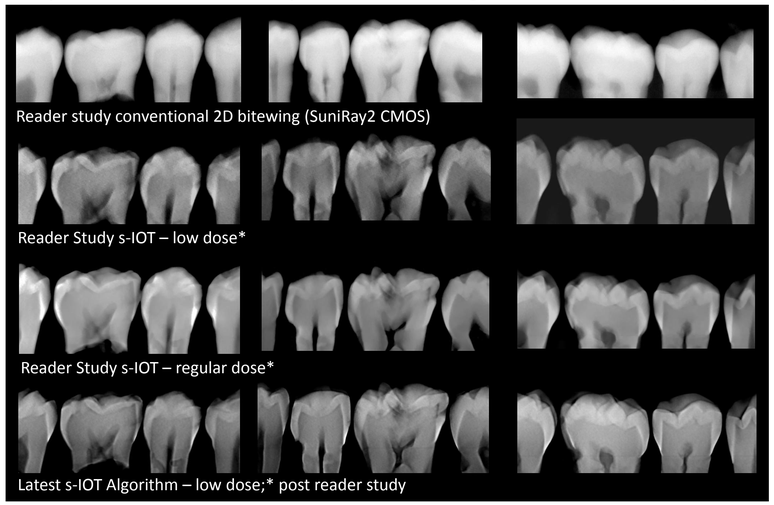
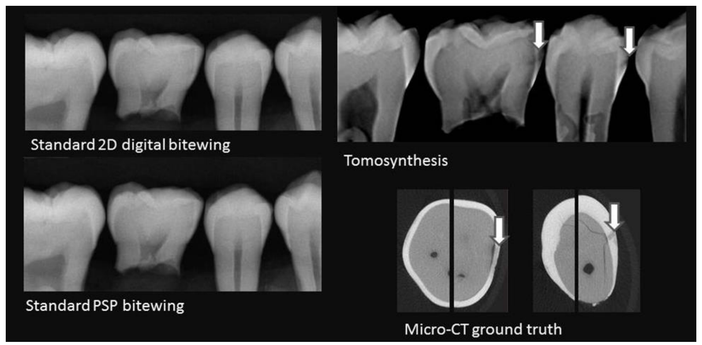
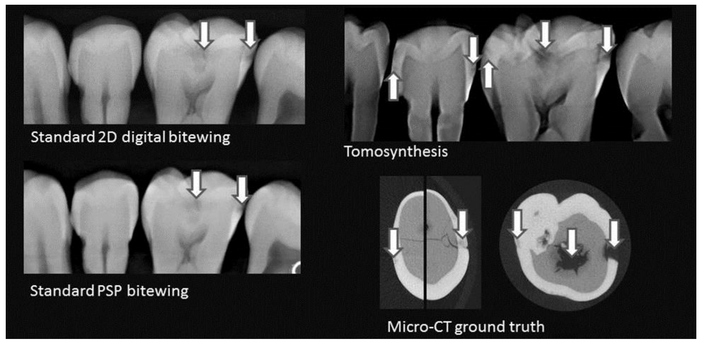


Figure 1. Comparison of 2D bitewing radiographs, s-IOT images at two different dose levels, and the latest reconstruction algorithm s-IOT images (post observer study).

***Dose Definitions:** "low dose" acquisition equal to PSP or F-speed film single acquisition exposure; "regular dose" acquisition equal to 2xD-speed film single acquisition exposure





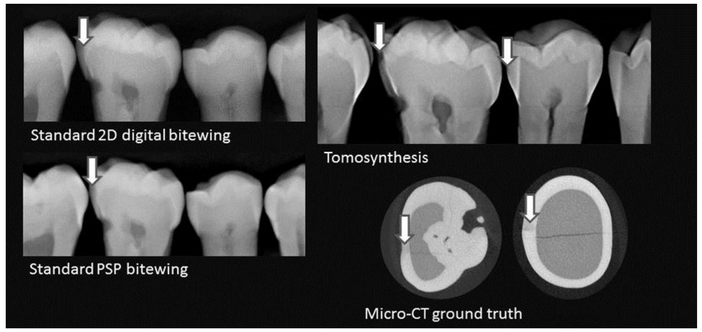


Figure 2. Comparison of other 2D intraoral bitewing images with s-IOT using extracted teeth. 2D intraoral images were acquired using a direct digital sensor and photostimulable phosphor (PSP). Micro-CT axial images display ground truth lesion status. Arrows on the 2D and s-IOT images indicate visible caries lesions. Arrows on the micro-CT images indicate confirmed lesions.

Results

- ANOVA showed statistically significant differences between ROC areas under curve, with s-IOT *regular* outperforming 2D and s-IOT *low* (0.84 vs. 0.77 and 0.77)
- Differences in sensitivity between modalities were statistically significant, with s-IOT *regular* outperforming 2D and s-IOT *low* (0.57 vs. 0.42 and 0.48)
- Differences in specificity between modalities were statistically significant, with s-IOT *low* having a lower specificity than 2D and s-IOT *regular* (0.95 vs. 0.99 and 0.97)
- Results are summarized in Table 1

Table 1. 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)

Conclusions, Future Directions

- The results of the observer study show a remarkable increase in sensitivity as compared to previous studies without a sacrifice in specificity
- We expect the 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
- Final tomosynthesis acquisition dose is expected to be comparable to current PSP or F-speed film doses

References

1. Shan J, Tucker AW, Gaalaas LR, et al. Stationary intra-oral digital tomosynthesis using a carbon nanotube X-ray source array. *Dentomaxillofac Radiol* 2015; 44: 20150098.

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Conflict of Interest: OZ has equity ownership and serves on the board of directors of Xintek, Inc., to which the following technologies used or evaluated in this project have been or will be licensed: CNT X-ray source arrays and s-IOT. JPL has equity ownership in Xintek, Inc. All listed authors are inventors of a pending patent application on s-IOT technology. All activities have been approved by institutional COI committees.