

# Monitoring Early Occlusal Caries on Primary Teeth with Optical Coherence Tomography

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## Introduction

- Early occlusal caries are diagnosed with visual-tactile methods, using the explorer, and possibly radiographs. These methods have been found to be unreliable and have risks for false positives.<sup>1-2</sup>
- Optical Coherence Tomography (**OCT**) is an imaging method that can capture 3D cross-sectional images of structures in the oral cavity.<sup>3</sup> It works by using near-infrared light (1300 nm) to quantitatively measure light scattering coming from different layers of tooth and mineral changes of carious lesions.<sup>4</sup>
- Aim:** To assess structural changes and lesion activity of early occlusal pit and fissure caries on primary teeth using OCT following remineralization.
- Hypothesis:** OCT will be able to successfully detect early occlusal caries, measure severity by visualizing its depth, and monitor changes in lesion structure by identifying the presence of a transparent surface zone of reduced reflectivity that is indicative of an arrested lesion.

## Methods

**Study Participants:** 29 participants (n=29 with 59 primary molars) recruited from the UCSF Pediatric Dentistry Clinic.

- Inclusion Criteria:** Aged 6 to 10; High caries risk; Must have at least two primary teeth with suspected pit and fissure caries; Living in areas with community fluoridation (to eliminate water fluoridation as a potential confounding variable).
- Exclusion Criteria:** Obvious cavitations or lesion severity that requires restorative treatment; Existing restorations covering pits and fissures.

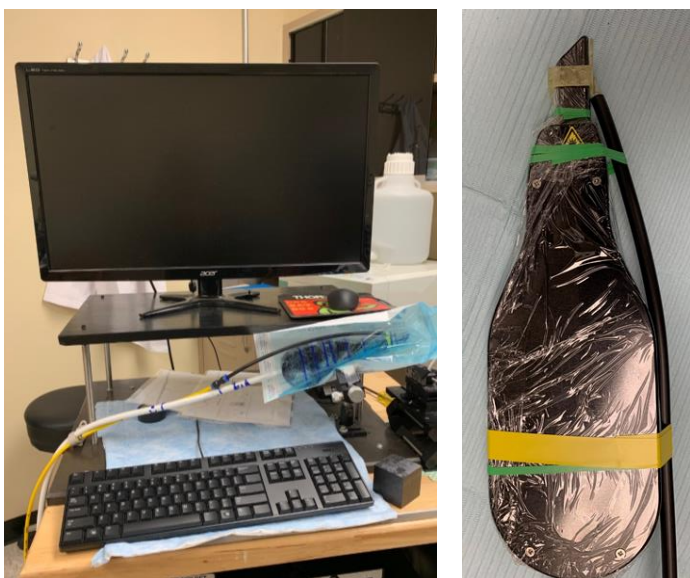
**Lesion Identification and Clinical Diagnosis:** Lesions were identified by the study investigator (pediatric dental resident) and was given a diagnosis according to the ICDAS codes<sup>5</sup> (Table 1).

Table 1. International Caries Detection and Assessment System (ICDAS)

ICDAS Code	Description
0	Sound enamel with no visible caries.
1	Visible initial changes in pit and fissures of enamel when air-dried.
2	Greater changes in enamel extending beyond pit and fissures, and lesions visible without drying with air.

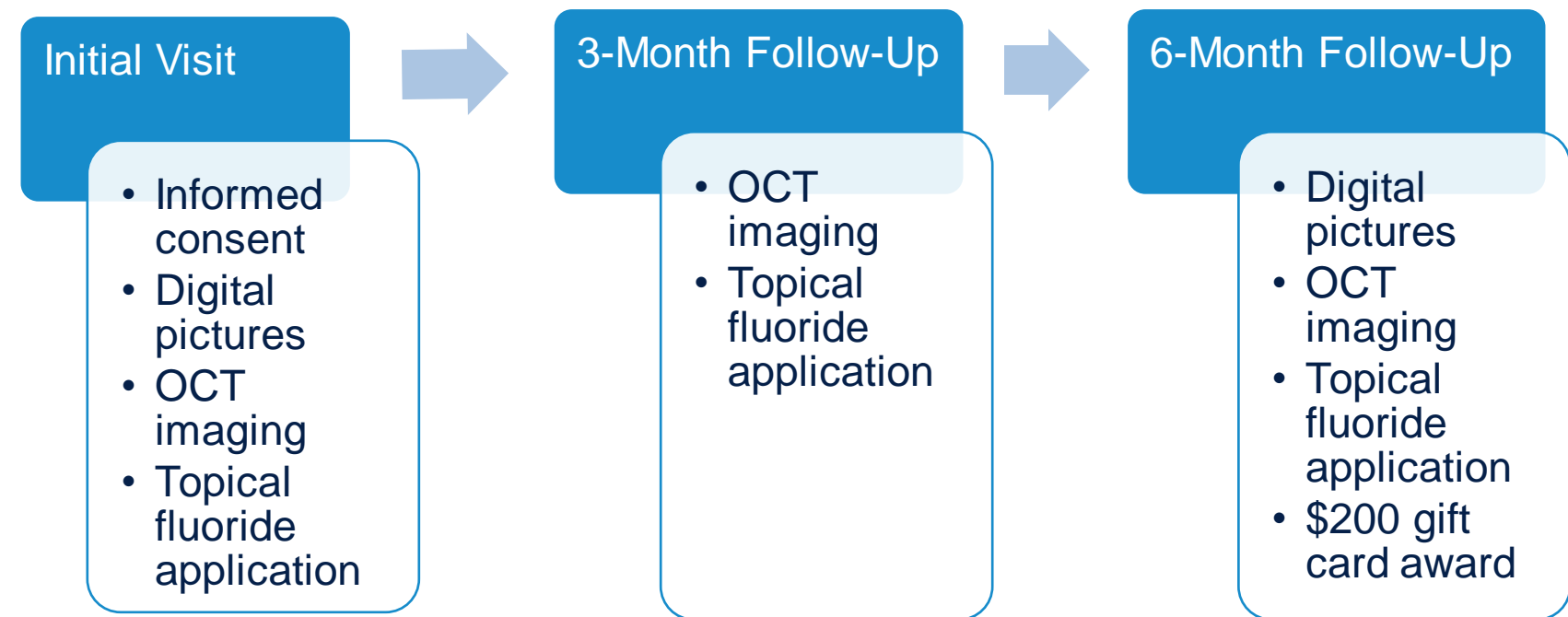
**Data Collection:** All lesions were monitored and scanned with OCT (Figure 1) during the 0-month, 3-month and 6-month visits (Figure 2).

- Two OCT scans were taken for each lesion.
- Fluoride varnish was applied to all lesions to promote remineralization after imaging at every visit.



**Figure 1. OCT System**  
Swept-source CP-OCT system from Santec (Komaki City, Japan) operating at a wavelength of 1310 nm was used with an autoclavable 3D-printed dehydration attachment made with dental resin to acquire clinical images. The OCT system acquired 3D images 6 x 6 mm<sup>2</sup> and 7 mm in depth.

Figure 2. Data Collection Process



**Image Analyses:** OCT images were converted and processed with MATLAB, and further analyzed with Dragonfly 2021.1 from ORS (Montreal, Canada). Manual image registrations, including rotation, translation, and scaling transformation, were performed.

- Caries Depth:** Lesions were classified according to its depth (Table 2).
- Transparent Surface Zone Presence:** Presence of a surface zone was evaluated on a binary scale (Yes/No).

Table 2. Caries Depth Classifications

Caries Depth	Description
E1	Less than half way through the enamel.
E2	More than halfway through the enamel.
D1	Penetration into the dentin.

## Results

**Initial Visit:** Clinically, all 59 teeth had visible lesions (56 teeth (95%) with ICDAS code 1, 3 teeth (5%) with ICDAS code 2).

From OCT scans, 58 teeth (99%) had pit and fissure lesions. One tooth (1%) did not show any lesions on OCT, although it was clinically diagnosed as ICDAS code 1 (False Positive) (Figure 3).

**3-Month and 6-Month Follow-Up:** OCT scans showed changes in lesion depth and activity over 6 months (Table 3, Figure 4-6).

Table 3. Caries Depth and Presence of Surface Zone Visualized in OCT Images

OCT Images	0-Month N=58 Teeth	3-Month N=58 Teeth	6-Month N=58 Teeth
<b>Caries Depth:</b>			
• E1	44 (76%)	44 (76%)	40 (69%)
• E2	10 (17%)	12 (21%)	16 (28%)
• D1	4 (7%)	2 (3%)	2 (3%)
<b>Transparent Surface Zone Presence:</b>			
• No	44 (76%)	33 (57%)	34 (59%)
• Yes	14 (24%)	25 (43%)	24 (41%)

Figure 3. Tooth with No Lesion Shown on OCT (False Positive)

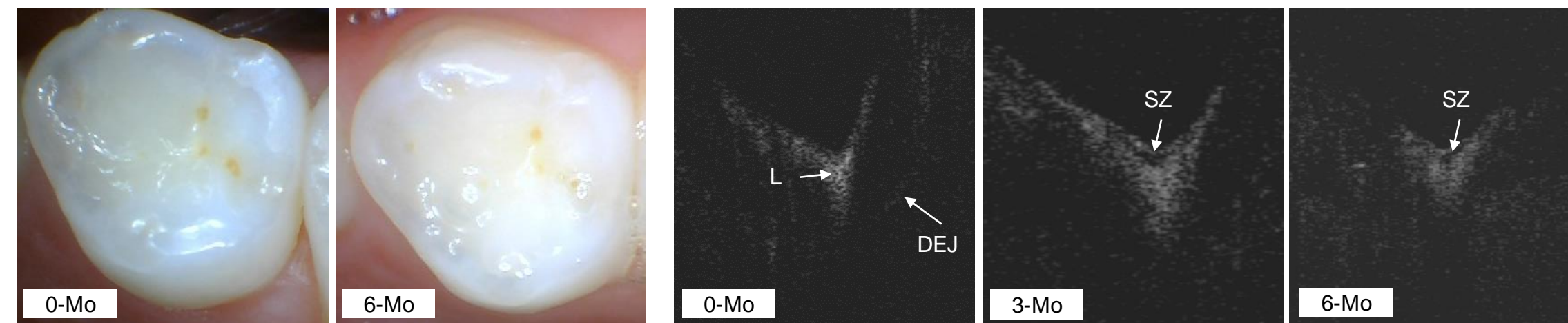


Figure 4. Positive Change in Lesion Activity from Active to Arrested in 6 Months

- Tooth #I was suspected to have an early occlusal pit and fissure caries (ICDAS code 1).
- Initial OCT scan:** Increased light reflectance in the distal pit denotes existence of carious lesion (**L**) with D1 depth (approaching the dentino-enamel junction (**DEJ**)). There is no surface zone (active lesion).
- OCT scan at 3 and 6 months:** A transparent surface zone (**SZ**) has formed (arrested lesion).

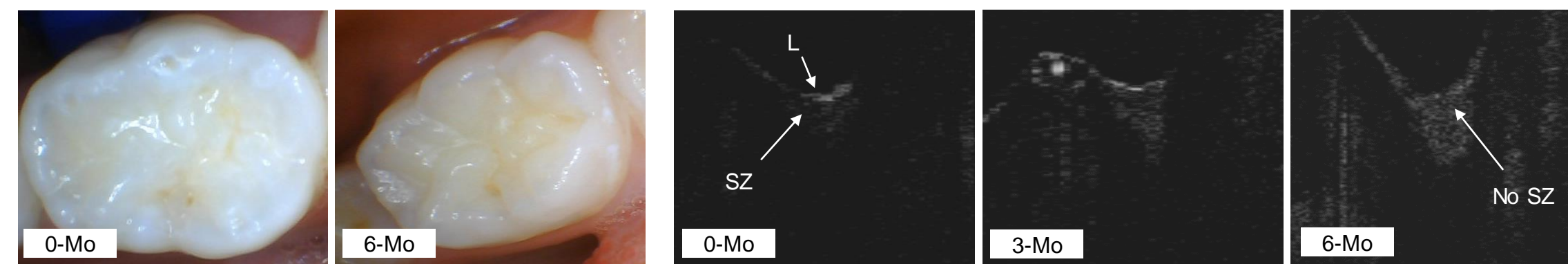


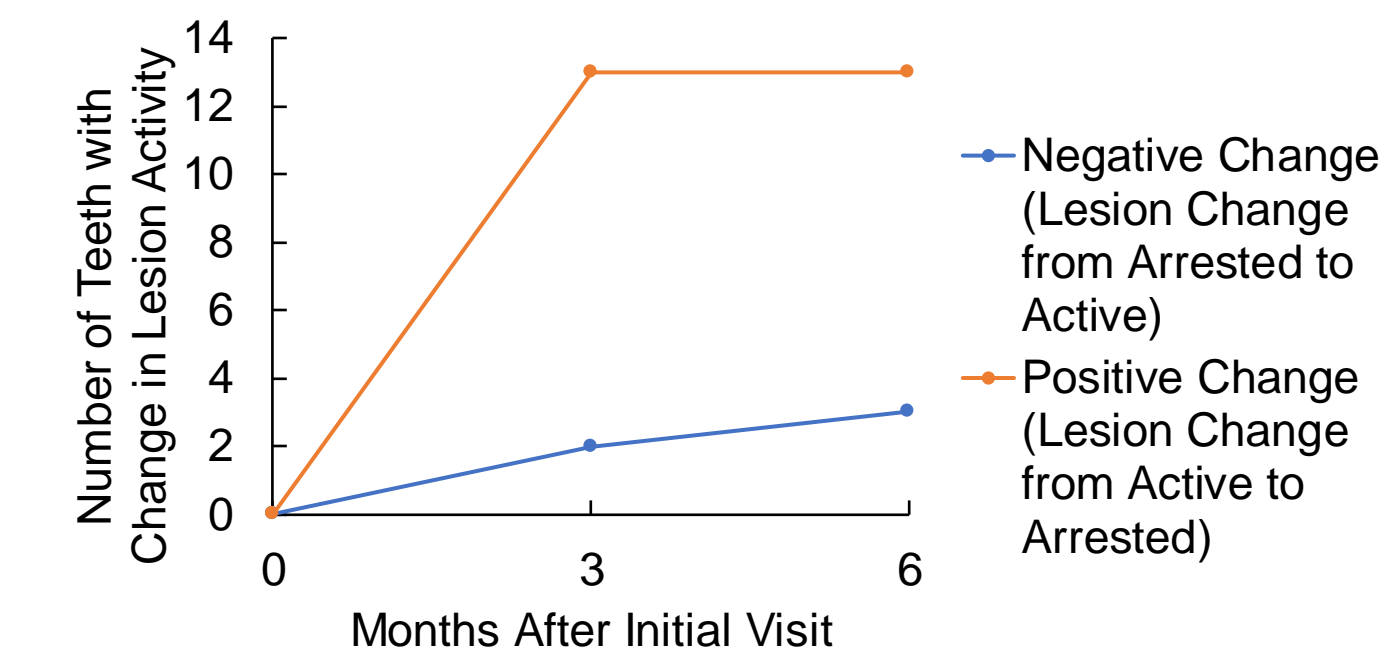
Figure 5. Negative Change in Lesion Activity from Arrested to Active in 6 Months

- Tooth #T was suspected to have an early occlusal pit and fissure caries (ICDAS code 1).
- Initial OCT scan:** Caries lesion (**L**) with depth of D1 present in the lingual pit, with a transparent surface zone (**SZ**) (arrested lesion).
- OCT scan at 3 and 6 months:** There is an increase in surface area with light reflectance and the transparent surface zone (**SZ**) has disappeared (active lesion).

### 6-Month Results Summary:

- Clinically, all 59 teeth did not show significant changes, according to its ICDAS diagnosis.
- From OCT scans, 16 teeth (28%) showed changes in lesion activity (Figure 6):
  - Positive change in 13 teeth (81%) (active to arrested)
  - Negative change in 3 teeth (19%) (arrested to active)
- No activity changes were seen in 42 teeth (72%):
  - 31 teeth (74%) remained active
  - 11 teeth (26%) remained arrested

Figure 6. Change in Lesion Activity Over 6 Months



## Conclusions

- OCT can detect early occlusal caries that cannot be identified through clinical exam or radiographs.
- OCT can visualize lesion depth through enamel and dentin layers.
- OCT can assess lesion activity (active vs. arrested) by detecting a transparent surface zone, which is indicative of arrested lesions.

## Acknowledgement

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## References

- Penning C, van Amerongen JP, Seef RE, ten Cate JM. Validity of probing for fissure caries diagnosis. *Caries Res.* 1992;26(6):445-449.
- Espelid I, Tveit AB, Fjellveit A. Variations among dentists in radiographic detection of occlusal caries. *Caries Res.* 1994;28(3):169-175.
- Otis LL, Everett MJ, Sathyam US, Colston BW. Optical coherence tomography: A new imaging. *J Am Dent Assoc.* 2000;131(4):511-514.
- Fried D. Lasers and optics for measuring tooth decay. *OPN Opt Photonics News.* Published online 2010;15-19.
- Ismail AI, Sohn W, Tellez M, et al. The International Caries Detection and Assessment System (ICDAS): an integrated system for measuring dental caries. *Community Dent Oral Epidemiol.* 2007;35(3):170-178.