



Optical Coherence Tomography Evaluation of Deep Dentin Crack Removal Techniques

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Objectives

The aging and mastication stresses induce microcracks in the dental hard tissues, potentially leading to tooth fracture. There are currently no standard clinical procedures for observation and removal of these cracks. This in vitro study aimed to use optical coherence tomography (OCT) for non-invasive evaluation of the effectiveness of current clinical techniques to remove deep coronal dentin cracks.

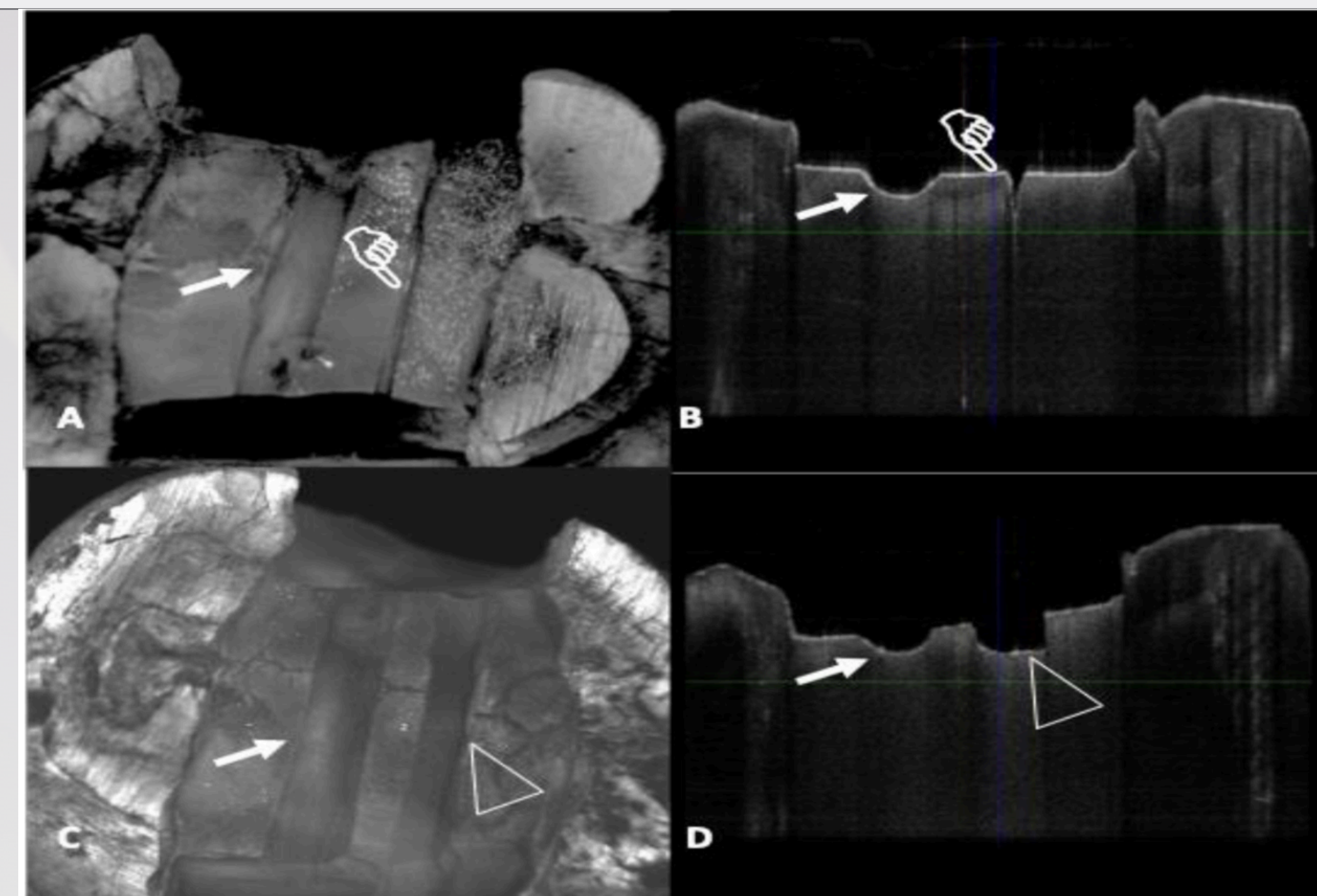
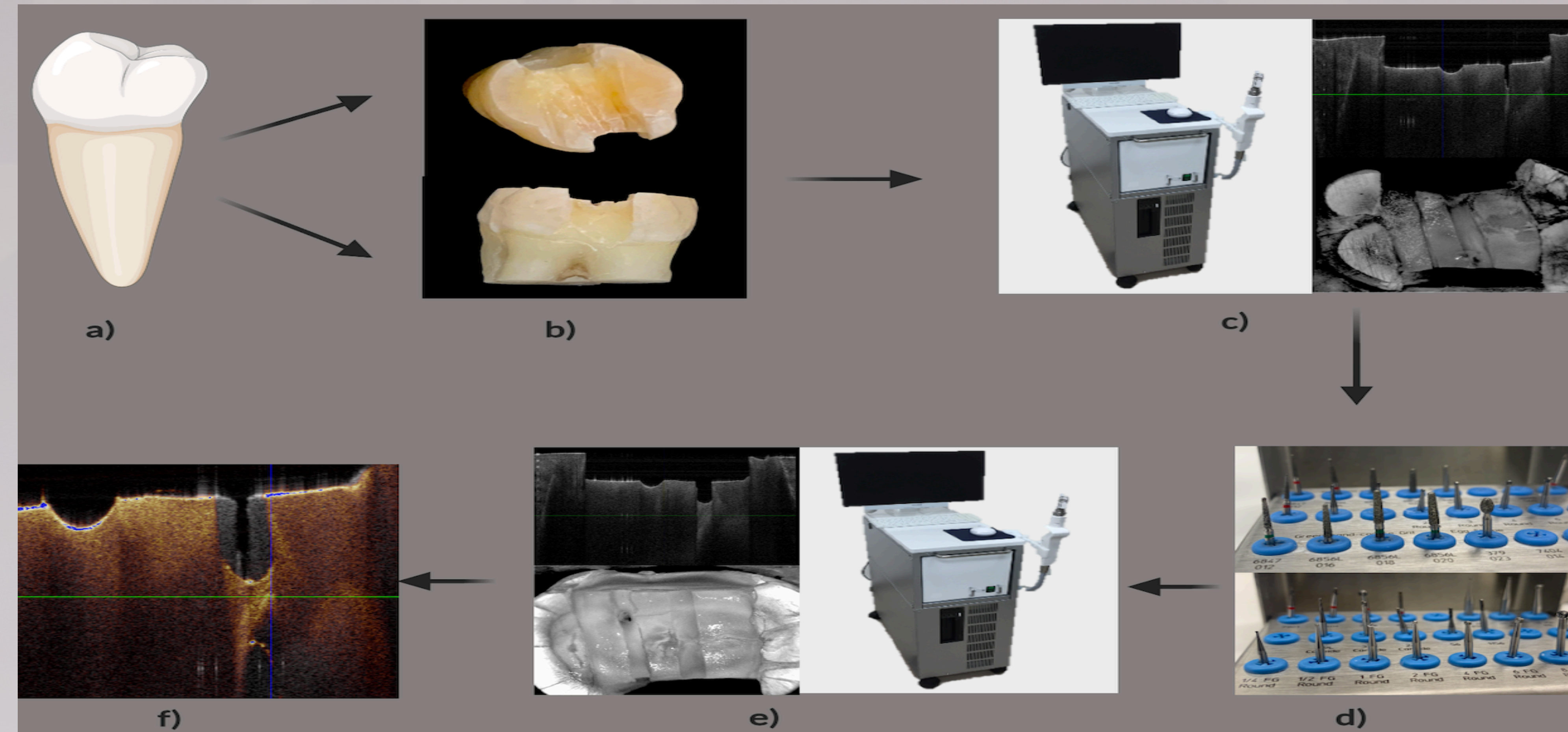
Method 1: Specimen Preparation with Diamond Disc

At the time of the experiment, the cusps on all teeth were reduced flat by 1 mm, and a 4 mm-wide and 2-mm deep channel was created at mid-coronal dentin with two proximal boxes using a wheel-shaped diamond bur attached to an electric dental hand piece (NSK, Japan) at 150,000 round per minute (RPM) under water spray cooling. A guide notch was then created over the pulpal floor dentin extending mesiodistally using the tip of a fine diamond bur (#8862, Komet, USA) as a reference landmark. A diamond disc (Medium HyperFlex Double Sided Diamond Disc, Brasseler, USA) with a cutting head thickness of 140 μm was then used to simulate a mesiodistal dentin crack with an approximate depth of 0.7 mm on the pulpal floor.

Methods 2 : Optical Coherence Tomography (OCT)

Three dimensional OCT scans were obtained from the occlusal surface of the specimens over an 10×10 mm window using a prototype swept-source OCT system (Yoshida Dental, Japan) with the center and range wavelengths of 1310 nm and 140 nm respectively, and a frequency of 50 KHz. The system optical resolution was 11 μm in depth, for a medium with hypothetical refractive index of $n = 1$. The OCT handheld scanning probe was placed at a predetermined distance from the specimen projecting the scanning beam to the experimental surface. The 3D scan with this configuration can be obtained in <4 s over an optical depth of 8 mm and $400 \times 400 \times 2048$ voxel data.

OCT scans were collected pre-treatment, as well as post-treatment and were compared by Amira 3D software.



Results and Discussion 1

The dimensions of the removed dentin structure as a result of crack treatment were the largest in the particle abrasion group exhibited by the average removal depth and width of 1,124 and 1,017 μm , respectively which was significantly different from all bur groups (Man-Whitney, $p < 0.005$). On the other hand, particle abrasion resulted in smallest crack propagation in each dimension, which was significantly different from all bur groups (Man-Whitney, $p < 0.01$). Removed dentin depth and width were different among burs ($p < 0.05$) and ranged from 161 to 315 μm , with #1156 creating the deepest removal of all burs. The removed width ranged from 408 to 991 μm , with 1/2 round bur the smallest width followed by #8847 and #1156 burs. All burs resulted in a degree of crack formation and there was no difference in crack dimensions among bur groups ($p > 0.05$).

Our study is for the first time using OCT for comprehensive analysis of dentin micro cracks. OCT is a non-invasive cross-sectional imaging technique that determines backscattered light along with echo time delay. The instrument in the current study is a new implementation of particle air abrasion with improved control due to smaller nozzle size as well as an adjustable simultaneous water spray. While the crack frequency and size was diminished by the particle abrasion, the dimensions of removed dentin were much greater compared to bur treatments, which indicates less control while removing the initial dentin crack compared to bur treatments.

Conclusions

Each bur type used throughout this experiment induced new cracks, but the volume of removed dentin was significantly different between groups depending on the shape of the bur, a variable that should be considered for clinical situations. Air particle abrasion was the most effective removal technique and should be given consideration when applicable. Clinicians must be aware of crack propagation under various techniques and implement a plan to reduce it as much as possible.

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