Optical Coherence Tomography

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KEYWORDS

• Optical coherence tomography • Dental OCT • SS-OCT • PS-OCT

KEY POINTS

- Optical coherence tomography (OCT) is a noninvasive diagnostic technique providing cross-sectional images of biologic structures based on the differences in tissue optical properties.
- Different types of OCT including TD-OCT, FD-OCT, SS-OCT, PS-OCT are discussed.
- OCT has several potential applications in dentistry.
- The main limitations for clinical use of OCT in dentistry are high cost and lack of commercial availability.

OPTICAL COHERENCE TOMOGRAPHY

Optical coherence tomography (OCT) is a noninvasive diagnostic technique providing cross-sectional images of biologic structures based on the differences in tissue optical properties. It was first reported by Fujimoto and colleagues[1] in 1991. It is an interferometric technique that uses near-infrared (IR) light waves that reflect off the internal microstructure in a way that, in principle, is analogous to an ultrasonic pulse echo. It is possible to obtain real-time images with excellent axial resolution (<10 μm).[2] OCT has been widely used in numerous clinical applications, including gastroenterology, ophthalmology, and dermatology and is becoming popular as a promising technology in dentistry.

OPTICAL COHERENCE TOMOGRAPHY TYPES AND SPECIFICATIONS

OCT combines light from a low-coherence broadband light source with an interferometer to produce cross-sectional images of tissue structures generated as a result of

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interaction between a partially coherent beam of optical radiation and tissue components.[1,3]

The early OCT systems were based on time-domain (TD) detection in which echo time delays of light were identified by measuring the interference signal as a function of time, while scanning the optical path length of the reference arm.[1,4] The light reflected from the sample and reference arms interferes within a Michelson or Mach-Zehnder interferometer. This interference signal is acquired by a photodiode or charge-coupled device that is dependent on the type of OCT. **Fig. 1** shows the first OCT type, TD-OCT. TD-OCT acquires various optical path lengths by moving a reference reflector.[5]

Another common type of OCT is the spectral domain OCT or Fourier domain (FD) OCT. A spectral domain OCT system is setup with almost the same components as TD-OCT but with an additional grating (for spatial Fourier transform), sensor array (usually charge-coupled device array), or spectrometer.[2] OCT has been revolutionized in recent years by the development of FD techniques that allow high-speed scanning without loss of sensitivity.[6] Swept-source (SS)-OCT is one of the implements of FD-OCT and uses a wavelength-tuned laser as the light source.[7] In SS-OCT, the spectrally resolved interference is derived from rapidly sweeping the wavelength of the laser. The high acquisition speed of SS-OCT, providing near real-time video-rate imaging while improving the overall signal-to-noise ratio of the acquired images, has made clinical applications of OCT more feasible.[8] In the authors'

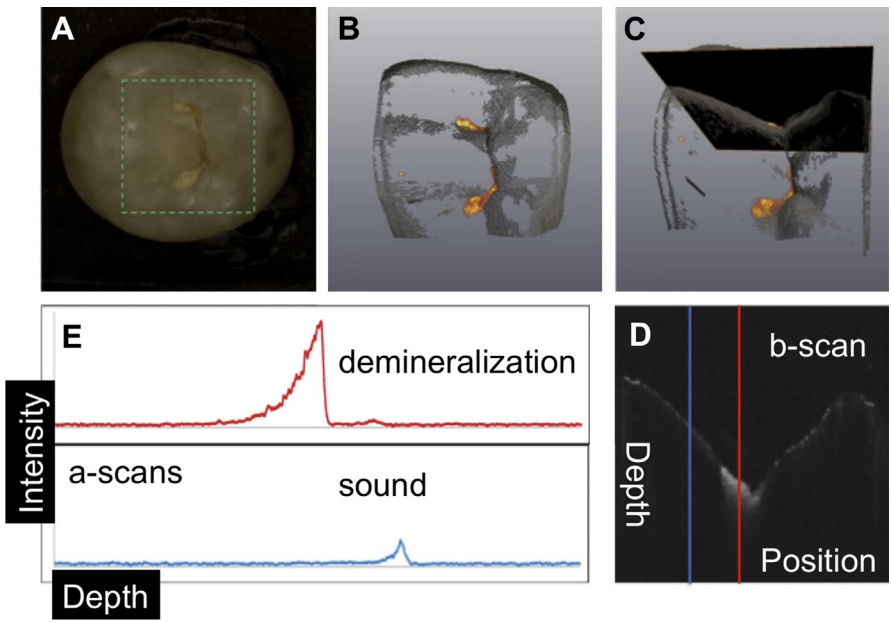

Fig. 1. A visible image of an extracted tooth (*A*) with demineralization in the fissure; a 5 × 5 mm box was cut to mark the region of interest. (*B*, *C*) Acquired CP-OCT three-dimensional scans segmented to show areas of demineralization (*red*/*yellow*). (*D*) A two-dimensional slice extracted from the image at the position indicated in *C* is shown. This is called a b-scan. The b-scan is displayed in grayscale with higher reflectivity in white corresponding to demineralization. (*E*) Two lineouts of depth versus intensity, called a-scans, were extracted (*red* and *blue lines*) at sound and lesion (demineralization) areas.