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NIR spectral absorption system for subsurface pulse detection combined with OCT for range finding of the inferior alveolar neurovascular bundle during dental implant surgeries

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Abstract

In dental implantology procedures, most computer-assisted navigation techniques rely on static preoperative cone-beam x-ray computed tomography of the patient's jaw. These techniques are known to introduce localization errors and do not benefit from *in situ* guidance. Implant viability is dependent on osseointegration, which improves with increased implant depth. However, drilling deeper in the jawbone carries the risk of damaging the Inferior Alveolar Neurovascular (IAN) bundle in the mandible. Implications of IAN damage for patients vary from temporary numbness to permanent loss of sensation in the lower facial area.

We have investigated the concept of combining Near Infra-Red (NIR) spectral absorption and Optical Coherence Tomography (OCT) in an optical fiber probe small enough to eventually fit into a surgical drill bit for real-time evaluation of the distance from the probe to the IAN. We designed a reflectance fiber probe to sense the pulsation of the artery in the IAN bundle, and a custom detection circuit board with very low bandwidth (10Hz) and noise (SNR=110dB), to overcome the challenge of measuring the weak cardiac pulse signal.

We tested the configuration on a custom phantom model of the jawbone with a closed-loop blood surrogate pumping circuit. Results indicate a potential detection range of 0.5-4 mm at 850 nm with a source-detector separation of 0.6-1.8mm. Swept-source OCT at 1.3µm provides finer resolution sensitivity to the proximity of the IAN bundle in the 0-0.9mm range. Instrumentation as well as methods for acquiring, calibrating and processing the data to provide robust range-finding capability will be discussed.

Biography

Francois Baribeau received the B.A.Sc. in engineering physics and the M.Sc. degree in electrical engineering from Laval University, Quebec City, Canada in 1991 and 2001, respectively. His M.Sc. research was on silicon photonics at the Center for Optics Photonics and Lasers (COPL) of Laval University. He worked as a research engineer for several private companies and as a lecturer on optoelectronics before joining INO's Biophotonics group in 2010. He is currently involved in NIR sensing and imaging, fluorescence detection and optical phantoms metrology.