Advancements in Optical Coherence Tomography in Clinical Applications

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Abstract: Optical Coherence Tomography (OCT) has evolved from a high-resolution, non-invasive "optical biopsy" tool into a cornerstone of modern medical diagnostics and image-guided therapy. Driven by advancements to ultra-high-speed swept-source systems, OCT now provides not only near-histological anatomical detail but also critical physiological insights through functional extensions. The most transformative of these is OCT Angiography (OCTA), which offers non-invasive, depth-resolved visualization of microvasculature, revolutionizing the management of vasoproliferative diseases. In ophthalmology, OCT is the undisputed standard of care and is advancing into the operating room, where microscope-integrated intraoperative OCT (iOCT) provides real-time surgical guidance. In cardiology, intravascular OCT (IVOCT) delivers unparalleled resolution for characterizing vulnerable atherosclerotic plaques and optimizing coronary stent placement, significantly impacting interventional strategies. The technology's reach is rapidly expanding, establishing new diagnostic paradigms in other specialties. In dentistry, it enables early, non-ionizing detection of caries and restoration defects. In otolaryngology, it visualizes middle ear structures through the tympanic membrane and assesses vocal fold pathology, guiding delicate procedures. Furthermore, in oncology and gastroenterology, endoscopic OCT is pioneering non-invasive surveillance of precancerous conditions like Barrett's esophagus and guiding tumor margin assessment. The latest frontier involves integrating OCT with artificial intelligence for automated analysis, promising to further extend its clinical impact across medicine.