Oral Diagnosis

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Editors

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Minimally Invasive Imaging Approaches

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Preface

The human race has made great progress in the quest to understand nature and harness its mysteries to improve our daily lives. It is fascinating, indeed, to note that our exploration at the extreme scales, from subatomic particles to distant galaxies, has a common vein: "light." Tremendous recent advances in optics and photonics are ushering in formidable new technologies, enabling personalized and precision medicine approaches to improve human health. This book represents an effort to provide a clinically focused overview of clinical applications of light in dentistry with an emphasis on clinical imaging techniques.

Optical imaging permits in vivo, real-time, non-perturbing, or minimally perturbing inspection of tissues, allowing safe and repeatable examination of biological tissues using non-ionizing imaging sources. Broadly speaking, optical imaging can be categorized as the ability of light to interrogate biological tissue by either diffusive (passive) or ballistic (active) interactions. The former modality is evident in interferometric approaches that largely depend on light reflection, refraction, and transmission, while the latter modalities are predominantly based on absorption, emission, excitation, as well as scattering. Some practical uses of these modalities include traditional intraoral cameras (digital dentistry), surgical loupes and microscopes, as well as laser Doppler techniques. Intraoral applications of new modalities such as optical coherence tomography (routinely used in ophthalmology), Raman spectroscopy, fluorescence imaging, photoacoustic imaging, and near-infrared spectroscopy have been investigated more recently. Ongoing advances in laboratory-based innovations such as super-resolution microscopy and multiphoton imaging still require translational efforts before they become suitable to human applications.

Among medical specialties, dentistry presents a challenging biological scenario where both hard (mineralized) and soft tissues play integral roles in enabling optimal craniofacial functions. The oral cavity is perhaps the best exemplar of all human mineralized hard tissues, with structural components ranging from the hardest known tissue, enamel, to the considerably softer dentin, cementum, bone, and cartilage. The oral soft tissues include specialized parakeratinized mucosa that provides resistance to physical (masticatory) compressive and shear forces, as well as non-keratinized lining mucosa. The latter includes specialized secretory glandular epithelium that produces saliva. There also exists an intermediate transitional epithelium between the oral mucosa and skin termed the vermillion (lip) border. A rather unique

feature in the oral cavity, not present in any other anatomical site, is the anchoring of the tooth within a bony socket (alveolar bone) by means of a complex soft tissue (gingiva) and tooth attachment. This gingival attachment presents a unique mechanical, biological, and immunological niche that predominantly defines the progression of gingival and periodontal disease. Hence, these complex anatomical oral and dental structures present unique diagnostic challenges that require sophisticated hard and soft tissue imaging approaches to inform on and enable accurate interpretation of their health status, form, and structure.

The pathophysiological functions of the oral cavity involve an intricate interplay of the mechano-physical (occlusive, masticatory), fluid (saliva), immunological, and polymicrobial environment of the oral cavity. The latter, termed the oral *microbiome*, has opened new vistas in our understanding of oral-systemic health connections, giving new credence to the phrase the *oral health is a window into one's general health*. Imaging technologies that inform on the precise composition and functions of oral biofilm serve as powerful tools to gaining insights into its structure and function in healthy and pathological scenarios such as developmental anomalies, infections, injury, and malignancies. All of these necessitate early and precise diagnoses and monitoring.

An exciting future expansion of applications for innovative imaging modalities is the potential combinatorial approach of merging *thera*py with diag*nostics* termed *theranostics.* Therapeutic applications of biophotonics devices will potentially transform conventional restorative and prosthetic dentistry techniques through innovations such as direct combinatorial image-guided interventions and an exciting new focus on regenerative clinical dental applications. The innovations in optical and photonic technologies highlighted in this book provide clear evidence that clinical dentistry is well poised to play a leading role in healthcare innovation. The editors and contributors to this book are well known for their original contributions to the field of dental optical imaging. Overall, this book represents their sterling effort to showcase the current state of the art in optical imaging as applied to oral health. This book should be a very useful resource for dental clinicians and dental researchers alike in enabling safe, efficacious, and optimal oral health in the modern clinic.

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