The Future of Healthcare with Optical Biomedical Imaging

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Medical Imaging: Research & Development Saving Lives

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Optical Society of America
Goal for Imaging Technology: 
*Image and diagnose disease at the earliest stage*
Optical Biomedical Imaging can:
- Improve quality healthcare
- Reduce healthcare costs

Optical Biomedical Imaging has been driven by:
- Federal research funding
- Investment capital

Optical Biomedical Imaging can:
- Open new job markets
- Improve our global competitiveness

Optical Biomedical Imaging can:
- Be a rich source of innovation
- Spawn new companies
Optical Biopsy of Tissue for Point-of-Care Microscopic Assessment

Change the Paradigm for Detection and Diagnosis
Optical Coherence Tomography (OCT)

Analogous to ultrasound imaging, but with near-infrared light

- Cellular-level resolution
- Real-time volumetric imaging
- Digital computational analysis
- Intra-operative & intra-procedure feedback

3-D Volume Acquisition

Dynamic Acquisition

1 mm

10 cm
Intraoperative OCT for Image-Guided Breast Cancer Surgery

► 1 in 8 U.S. women will develop invasive breast cancer in their lifetime
► In 2011, estimated 230,480 new cases of invasive breast cancer, with 39,520 deaths
► Following lumpectomy procedures, exceedingly high 20-40% re-operation rate
► Intraoperative margin assessment with OCT offers potentially >$175M direct annual savings

Breast Tumor Margins
Lymph Nodes
Needle Biopsies

NIH – National Institute of Biomedical Imaging and Bioengineering – R01 EB012479
Surgical Handheld Optical Imaging Probe

OCT ISAM

Breast Tissue

Human Breast Tissue

Section A

Beam Focus

Section B

Histology

Raw data

ISAM corrected

ISAM: Interferometric Synthetic Aperture Microscopy – Computed Imaging of Histology

Motivation for this Research

Objective
Development of an advanced hand-held optical imaging instrument and system for use in the primary care office or general medical clinic.

Office Visit by Physician Specialty 2006

- General and Family Medicine: 23.1%
- Internal Medicine: 13.9%
- Pediatrics: 13.6%
- Obstetrics and Gynecology: 7.7%
- Ophthalmology: 6.4%
- Orthopedic Surgery: 5.3%
- Oncology: 1.6%
- All others: 28.4%

Source: CDC/NCHS
Motivation for this Research

Result

- Number of office visits increases dramatically in aging population, which is expected to only continue to increase in the future.

- Majority of office visits are for diagnostic and screening services.
Initial Targets:

- Middle-ear biofilms in ear infections
- Diabetic retinopathy detection and monitoring

Office-based handheld 3-D OCT scanner with interchangeable tips for primary care imaging

NIH – National Institute of Biomedical Imaging and Bioengineering – R01 EB013723
Important Tissue Sites in Primary Care Medicine
Objective of this Research

Transform OCT Technology from a Diagnostic Modality into a Screening Modality

- Advancing technology at the front-line
- Screening general population (normal/not?)
- Quantitative monitoring of chronic diseases
- More efficient and economic referral

Advanced Handheld Probe

Compact OCT System
High speed, High resolution
Handheld Probe using a MicroElectroMechanical Scanner
How Does It Work?
In vivo OCT and Video Images (Human)

(A) nail fold  (B) uvula  
(C) gum  (D) arm  (E) cornea
(F) tympanic membrane  
(G) retina around fovea  
(H) optic nerve head

Nguyen, et al., Biomedical Optics Express 1:1104, 2010
Noninvasive Optical Assessment of Biofilm Growth in the Middle Ear

Finding and Treating the Source for Chronic Ear Infections
Ear Infections

Otitis Media (OM) – Ear Infection
Most frequent diagnosis for all children
80-90% have $\geq 1$ infection by age 3
46% have $\geq 3$ infections by age 3

Complications
Hearing loss, speech & language delays

Treatment
Antibiotics, surgery (tympanostomy), supportive care

Age-standardized disability-adjusted life year (DALY) rates from otitis media by country (per 100,000 inhabitants)

Data from Mortality and Burden of Disease estimates for WHO member states in 2002

Bacterial Biofilms Cause Infections
Human Study

Normal

Infection with Biofilm

To Date:
68 Human subjects
10 normal, 78 abnormal
Ages 3½ to 80 years old

Automated Classification
98% Normal
2% Abnormal

Automated Classification
11% Normal
89% Abnormal
Obesity, Diabetes, and Diabetic Retinopathy

► One-third (33.8%) of U.S. adults are obese
► Over one-third of children and adolescents are obese or overweight

Reference: NHANES, CDC

► 1 in 10 (552 million) are expected to have diabetes by 2030
► 40-45% of diabetics will have diabetic retinopathy

Reference: International Diabetes Foundation
OCT Images from Diabetic Patients

Diabetic retinopathy results in thickening of retinal layers

- NFL: Nerve fiber layer
- GCL: Ganglion cell layer
- IPL: Inner plexiform layer
- INL: Inner nuclear layer
- OPL: Outer plexiform layer
- ONL: Outer nuclear layer
- IS: Inner segment
- OS: Outer segment
- RPE: Retinal pigment epithelium

Normal
Age 73, Female
Age 59, Male
Age 59, Male
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Nguyen CT, Tu H, Chaney EJ, Stewart CN, Boppart SA. Non-invasive optical interferometry for the assessment of biofilm growth in the middle ear. Biomedical Optics Express, 1:1104-1116, 2010.


Every effort was made to locate and cite the original website sources for the images used in this presentation.
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