A brief roundup of optical imaging

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Outline

- Naive optical imaging and variations
- Basics on contrast enhanced optical imaging
  - Methodology
  - Tracers
- Applications
  - Clinical applications
  - A precinical model study

Naïve optical imaging

How it all began – diaphanoscopy.

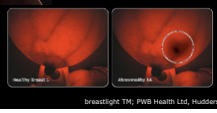


Cutler; Annals of Surgery, 1931
Brown Kelly; British Medical Journal, 1905

Naïve optical imaging

How is this still a thing?

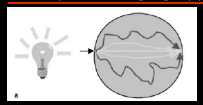




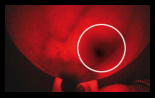
breastlight TM; PWB Health Ltd, Huddersfield, UK

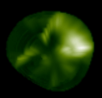
Naïve optical imaging

Optical imaging approaches – planar vs. tomographic

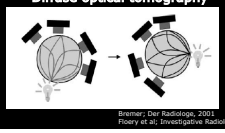


Diaphanoscopy





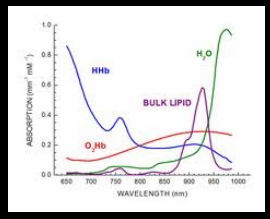
Diffuse optical tomography

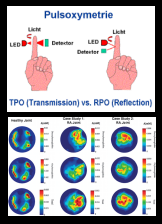


Bremer; Der Radiologe, 2001
Floery et al; Investigative Radiology, 2005

Optical spectroscopy

A reasonable use of absorption and scattering





Lasker et al; Biomedical Optics, 2002

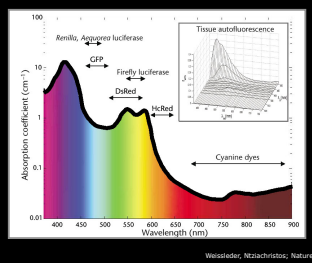
Contrast enhanced optical imaging

Different types of optical contrast

- **Autofluorescence and absorption**
- **Fluorescent proteins**
- **Fluorescent tracers**

Contrast enhanced optical imaging

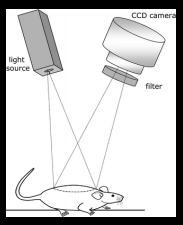
Why (near-infrared) fluorescence?



Weissleder, Ntziachristos; Nature Medicine, 2003

Some technical issues

Optical imaging approaches – fluorescence imaging

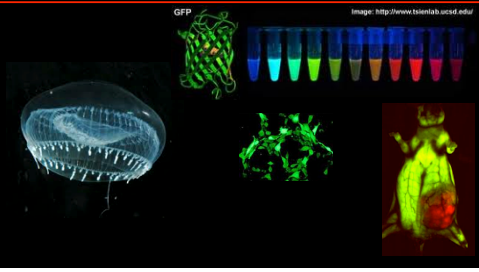


Illumination
⇩ Absorption
Excitation
⇩ „Fluorescence Lifetime"
Relaxation
⇩ Stokes Shift
Emission

Ntziachristos; European Radiology, 2003

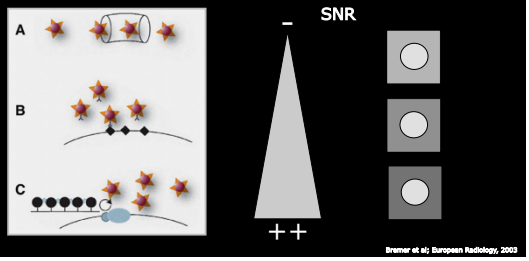
Contrast enhanced optical imaging

Intrinsic optical contrast – fluorescent proteins



Contrast enhanced optical imaging

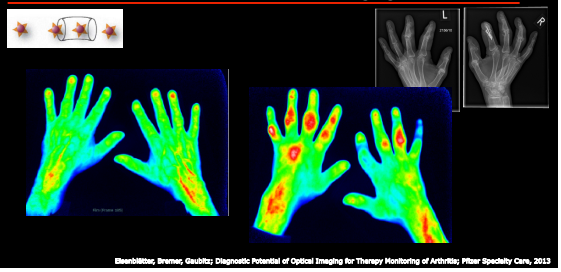
Different types of fluorescent tracers



Bremer et al; European Radiology, 2003

Application

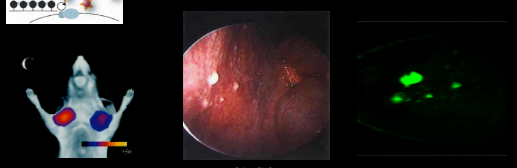
ICG –mediated arthritis imaging



Eisenblätter, Bremer, Gaubitz; Diagnostic Potential of Optical Imaging for Therapy Monitoring of Arthritis; Pfizer Specialty Care, 2013

Application

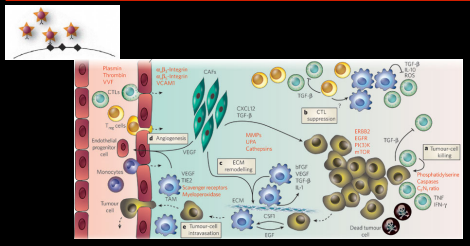
Protease-sensitive optical probes for endoscopy



Bremer et al; Nature Medicine, 2001
Seiden; Fox Chace Cancer Center, 2009

Research application

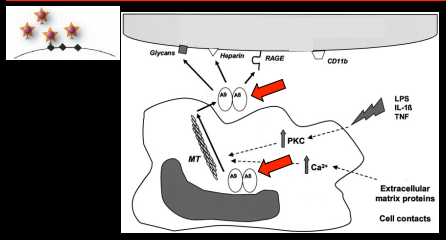
Potential target structures in cancer



Weissleder; Nature, 2008

Research application

S100A9 as an example for OI in preclinical research



Adapted from Foell, Roth; Arthritis Rheum. (2004)

Research application

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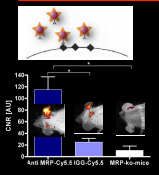
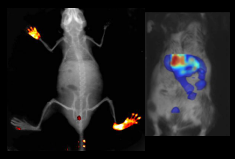
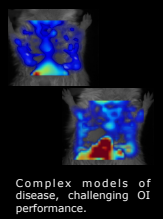


Proof of principle and assessment of specificity (S100A9-/-).

Inter- and intraindividual grading of disease activity and correlation with established clinical parameters.





Complex models of disease, challenging OI performance.

Vogl, Eisenblaetter et al; Nature Communications, 2014

Research application

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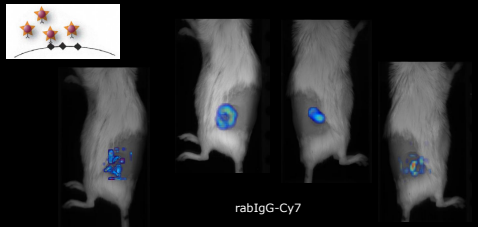

Becker, Große Hokamp et al; J of Nuclear Medicine, 2015

Research application

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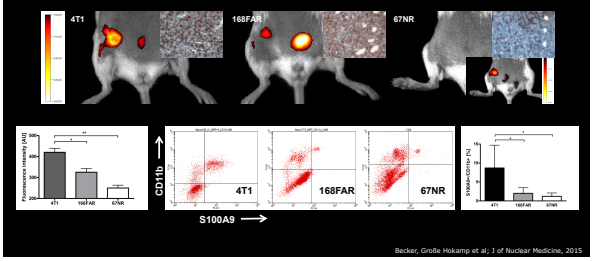

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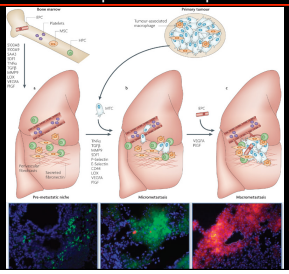

Psaila, Lyden; Nature Reviews Cancer, 2009

Research application

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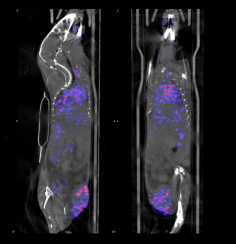

Female Balb/c mouse implanted orthotopically with 4T1 tumour cells; SPECT scan 24 h after aS100A9-In111 application

Eisenblätter, Schäffter; "The crosslink between inflammation and cancer visualised – evaluation of the contribution of the innate immune system to carcinogenesis and metastasis using *in vivo* imaging", CRUK 2012

Research application

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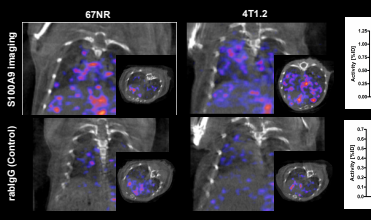
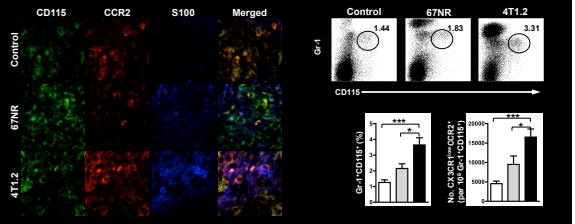


MRC MRL001640/1 „Molecular Imaging of the immune cell variety in malignant disease"

Research application

S100A9 as an example for OI in preclinical research



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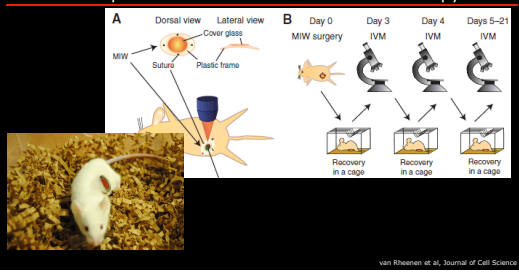
Research application

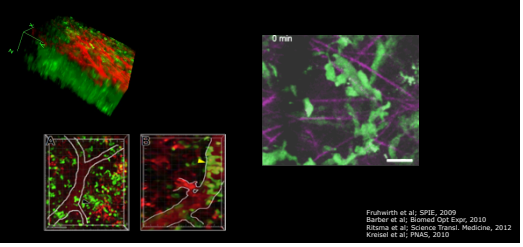
OI in preclinical research – intravital microscopy



van Rheenen et al, Journal of Cell Science (2011)

Research application

OI in preclinical research – intravital microscopy



Fruhwirth et al; SPIE, 2009
Barber et al; Biomed Opt Expr, 2010
Ritsma et al; Science Transl. Medicine, 2012
Kreisel et al; PNAS, 2010

Research application

Preclinical research concept – from OI to SPECT and back

Some things to remember

Basic facts on optical imaging

- Different ways to generate optical contrast (absorption/ scattering, fluorescence).
- Naive as well as contrast enhanced OI can be planar or tomographic.
- Fluorescence imaging requires intrinsic (proteins) or extrinsic (contrast agents) contrast media.
- Fluorescent tracers exist in different forms (perfusion, targeted, smart).
- Selected models permit multiscale imaging and validation.

Some things to remember

The role of OI in state of the art imaging research

- Ideal for initial testing and high throughput screening (no decay-related time limitation, very short scan times).
- Direct correlation with ex vivo methodology (FACS, fluorescence microscopy).
- Parallel imaging of multiple dyes allows for specificity testing.
- Systemic imaging still requires radionuclide labelling – labelling chemistry is virtually identical.

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Klaudia Niepagenkämper
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Thank You!

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