Endoscopic Measurement Head for OCT

OptoLab / Betreuer: Prof. Christoph Meier
Industriepartner: Damedics GmbH, Nidau / Experten: Prof. Dr. Volker M. Koch, David Aebi

Minimal invasive diagnosis and therapy for articular cartilage trauma and osteoarthritis is a cost effective and conservative approach. Cross-sectional imaging of the injured or worn cartilage would be a valuable tool for microstructure assessment. Optical Coherence Tomography is an appropriate modality due to its high image resolution with comparatively high penetration depth of 2-3mm.

Background

Osteoarthritis of the knee joint is a painful mechanical degradation and abrasion of the articular cartilage and the subchondral bone. It can be induced by cartilage structure irregularities and micro lesions. About one in ten individual is affected with early osteoarthritis in western countries which leads to considerable limitations of daily living. Today's arthroscopic treatment of osteoarthritis implies debridement (removal of damaged or infected tissue), lavage, analgesics (pain killers) or total knee joint arthroplasty (replacement) for severe degradations. But the usefulness and achievements of these procedures are questionable. Therefore, cartilage reconstruction or grafting is a demanded and an ongoing research topic. Virtual biopsy *in situ* by Optical Coherence Tomography OCT would be a valuable tool to assess cartilage thickness and abrasion degree and to detect micro lesions.

Project Scope

However, due to the restricted penetration depth of OCT, which is generally less than 3mm, it requires some type of endoscope probe for direct access to articular cartilage. The OCT laser beam has to be deflected at the proximal end of the endoscope in order to acquire cross-sectional images. The OCT scanning unit should be insertable into working channels intended for surgery tools. They are commonly no larger than 2mm in diameter. This limiting factor makes the mechanical scan probe design very challenging but also limits physically the maximal possible scan range.

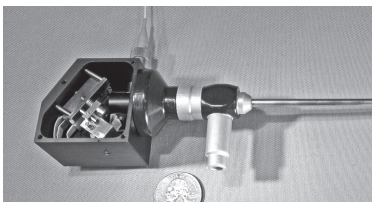
Results

In this thesis, an optomechanical setup was designed and realized by using a GRIN (gradient refractive index) relay rod lens to displace the scanning unit towards the distal end of the endoscope and therefore outside the human body. Thereby cross-section size and biocompatibility were considerably improved. A 2d MEMS mirror chip was implemented to provide 3d OCT volume assessment.

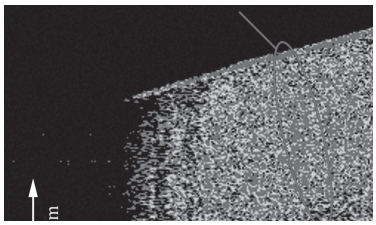
Discussion

An endoscopic OCT scanner prototype was produced and assembled, tested and characterized. The endoscopic OCT system has high signal sensitivity of 100dB and first OCT images of porcine cartilage gathered by the newly designed endoscope probe were exceedingly promising in the area of osteoarthritis and chondral irregularities. Cartilage thickness and structure abnormalities as small as 50 µ could be illustrated.

Peter Stalder
peter@stalder.ch



Unclosed OCT scanner integrated in dummy endoscope.



OCT cross-section with OCT endoscope of porcine knee joint with (A) the articular cartilage layer and (B) small cartilage fractures which cannot be seen at the surface.