nano-tera.ch
swiss scientific initiative in health / security / environment systems

SmartSphincter RTD 2013

FNSNF

Nano-Tera Annual Plenary Meeting, 4-5 May 2015

Biomechanical Model of the Human Anal Sphincter Complex

Tobia Brusa[1], Daniel Abler[1], Philippe Büchler[1],Lukas Brügger[2], Christian Gingert[3], Johannes Heverhagen[2], Franc Hetzer[3], and Bert Müller[4]

[1]Institute for Surgical Technology and Biomechanics (ISTB), University of Bern, Switzerland;
[2]University Hospital Bern, Switzerland; [3]Kantonspitäler Schaffhausen (KSSH), Switzerland; [4]Biomaterials Science Center, University of Basel, Switzerland

u b UNIVERSITÄT BERN

INSELSPITAL UNIVERSITÄTSSPITAL BERN HOPITAL UNIVERSITAIRE DE BERNE BERN UNIVERSITY HOSPITAL

spitäler schaffhausen

UNI BASEL

Introduction

- ***Fecal incontinence (FI)*** *describes the state of* ***involuntary loss of bowel content****. This includes flatus, mucus, liquid or solid feces.*
- *FI affects about 45% of retirement home residents and overall more than 12% of the adult population.*
- *Severe fecal incontinence can be treated by the implantation of an artificial sphincter.*
- *Tissue erosion, atrophy, infections or device malfunctions lead to long-term re-operation rates of 95% and definitive ex-plantation rates of 40%. This suggests that implants currently available on the marked fail to reestablish continence on the long run.*
- *The* ***development of a new implant*** *reproducing the capabilities of the natural sphincter is needed.*
- *A prerequisite for a* ***biomimetic implant design*** *is the* ***availability of the anatomy and the biomechanical parameters*** *of the human anal sphincter complex.*
- ***These parameters are not available in literature and are therfore assessed via a clinical study on healthy volunteers. Subsequently, this data serves as starting point for the development of the targeted biomechanical model.***

Hypothesis / Method

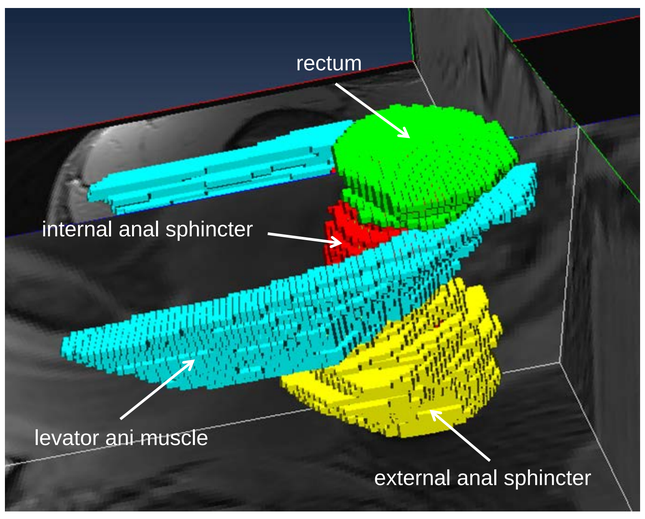
Human Continence Organ = Internal Anal Sphincter + External Anal Sphincter + Levator Ani Muscle

- *The* ***morphology*** *will be approached via* ***magnet resonance (MR)*** *and* ***ultra sound (US).***
- *The active* ***mechanical properties*** *will be extracted via* ***high-resolution anorectal manometry (HRAM)****, the passive compliance parameters, on the other hand, with the help of a* ***functional luminal imaging probe (FLIP)****.*

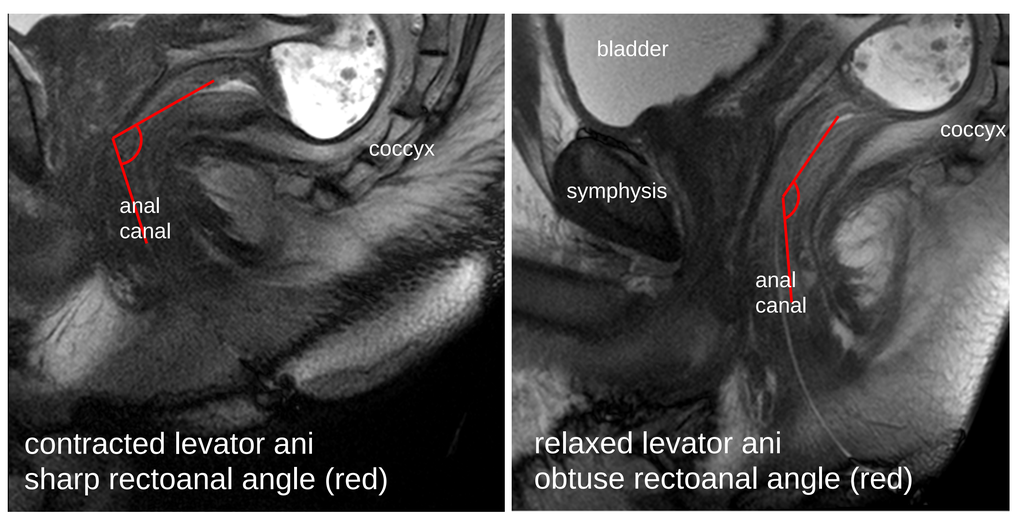
- ***MR****: provides an image of the complete pelvic floor with a spatial resolution in the mm range.*
- ***Rectoanal MR-coil****: provides sub-mm resolution with the draw back of a limited penetration depth.*
- ***US****: provides sub mm resolution but is accompanied by low contrast and a narrow penetration depth.*
- ***HRAM****: measures the pressure while the probe diameter is fixed.*
- ***FLIP****: measures the diameter of the anal orifice at different heights via impedance planimetry.*

Clinical Study / Results

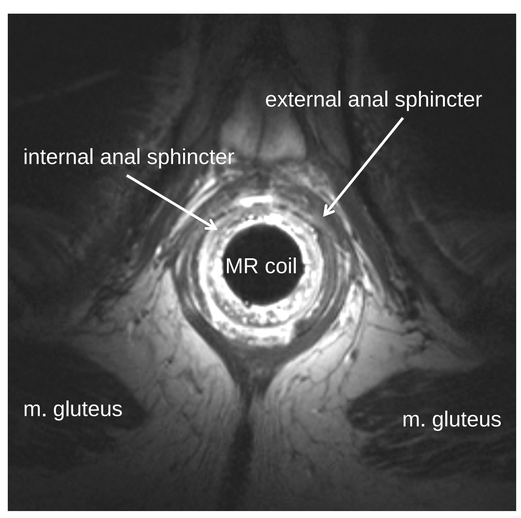
- *The clinical study on twenty healthy volunteers (10 women, 10 men) is currently running at the University Hospital of Bern.*
- *The last patient, aged 60 years or older and with a BMI between 20 and 30, is planned to be measured by the end of August 2015.*



3D reconstruction of the anal sphincter complex. T1-weighted image with a voxel size of 1x1x1mm³.



Medial sagittal slice (defecography) of the human pelvic floor.
T2-weighted defecography (4D) MR-image with a pixel size of 0.3x0.3mm².



Axial T2-weigted rectoanal MR-coil image with a pixel size of 0.5x0.5mm².

Conclusion / Next Steps

- *The preliminary morphological data analysis suggests that the* ***desired structures****, namely the internal anal sphincter, the external anal sphincter, and the levator ani,* ***can be extracted****. This data will be used to build a statistical shape model (SSM).*
- *The* ***assessment*** *of the required active and passive* ***mechanical properties*** *of the sphincter muscles is* ***possible*** *via HRAM and FLIP. In combination with the SSM the underlying biomechanical model will be established.*
- *The* ***movement****, caused by the contraction of the* ***levator ani muscle****, is* ***trackable****.*
- *It is* ***planned*** *to have the* ***clinical study extended onto patients*** *suffering from FI, adding the clinical component to the project.*