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Femtosecond Application in the
Restoration of Accommodation

Wavefront & Presbyopia Refractive Corrections Congress
February 14-17, 2008
Presbyopia - preconditions

Accommodation fails (according to Helmholz Theory):
- loss of elasticity
- harding of the lens tissue

However:
- Ciliary muscle stays active
- Lens capsule stay elastic
Presbyopia - preconditions

- Ray Myers and Ron Krueger first reported on the concept of laser modification of the crystalline lens in 1998
- First experimental results 2001 by Krueger et.al. with ns-pulses*


Accommodation fails (according to Helmholtz Theory):
- loss of elasticity
- harding of the lens tissue

However:
- Ciliary muscle stays active
- Lens capsule stay elastic
Concept of fs-Lentotomie

- overcome lens-hardening
- regain lens flexibility

Smooth µm cuts inside the crystalline lens to create gliding planes

fs laser pulse

cut

transparent tissue
cutting pattern inside the lens tissue
**Concept of fs-Lentotomy**

- overcome lens-hardening
- regain lens flexibility

Smooth μm cuts inside the crystalline lens to create gliding planes.

![Diagram of fs laser pulse cutting through transparent tissue](image)
Flexibility Increase on human donor lenses

Average increase: 97 (±23) μm*
Approx. ~ 2-3 dpt*
Setup of Lens deformation ability change

Fisher’s spinning lens test*

human donor lens 66 years

*Fisher, The elastic constant of the human lens, J. Physiol., 1971
Change of normalized thickness of human donor lenses after treatment

1620 rpm

Normalized lens thickness $\eta$ after laser treatment

Normalized lens thickness $\eta$ before laser treatment

Increase in normalized lens thickness

Decrease in normalized lens thickness

Increase in flexibility

Average normalized thickness change increases 16%

Maximum gain up to 67%
Existing wound healing animal study*

- 6 living Rabbit Eyes:
- Ring and starlike pattern

After 3 months, the rabbit lenses showed good transparency, with only 1 rabbit having cataract formation, unrelated to the laser.

*Krueger et al, First safety study of femtosecond laser photodisruption in animal lenses: Tissue morphology and cataractogenesis, J. Cataract and Refractive Surgery, 2005
In-vivo animal study

- preliminary results -
**In-vivo animal study**

**15 Chinchilla Bastard rabbits**
- fs-lentotomie treatment
  - Steering wheel pattern
- Treatment on one eye
- follow up in progress

**Investigations**
- OCT slit lamp*
- Scheimpflug images**

*SL-OCT™, Heidelberg Engineering GmbH, Germany
** Topcon SL-45, Topcon Optical Instruments, Japan
Results

- In all 15 rabbits the fs-lentotomie was successful
- Alignment of sedated rabbit eyes is challenging

rabbit A

post surgery
Results

- In all 15 rabbits the fs-lentotomie was successful
- Alignment of sedated rabbit eyes is challenging
- Pattern is fading 14 days post surgery

14 days follow up rabbit A

post surgery
OCT images

- Monitoring of the cut

post laser surgery

rabbit A
OCT images

- Controll of cataract formation

14 days post surgery

rabbit A
Scheimpflug images

• transparency of the lens is controlled to exclude pre-existing opacities and other abnormalities

pre surgery

rabbit B
Scheimpflug images

- transparency of the lens is controlled to exclude pre-existing opacities and other abnormalities

- Scattering due to laser cuts is clearly visible. Larger gas bubbles scatter stronger than small bubbles

post surgery

rabbit B
Scheimpflug images

post surgery

14 days follow up

rabbit B
Conclusion

- Increase of deformation ability of the lens after fs laser treatment
  - Direct anterior – posterior thickness increase

- Cutting inside *in-vivo* rabbit lenses was achieved
  - Alignment of sedated *in-vivo* rabbits/patients challenging

- OCT and Scheimplug images are a necessary and suitable tool for the cutting control

- 14 days follow up showed no cataract formation
  - Pattern is fading
  - Localized incisions and no spreading of defect visible

- Long term follow up (six month) in progress
  - Slitlamp, OCT, Scheimpflug, micromorphology
Thank you

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