

Technologies of Modern Contact Lenses

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Andreas Beeck



- Born 1989 in Lörrach
- Bachelor of Engineering at DHBW Lörrach, mechanical engineering
- Master of Science at University of Stuttgart, mechanical engineering
- Working on my PhD in applied optics at University of Stuttgart
- Since 2015 research and development at Hecht Contactlinsen GmbH

Hecht Contactlinsen GmbH



- Founded 1978
- Headquarter in Au at Freiburg im Breisgau
- 130 employees
- Manufacturer of individual hard and soft contact lenses



Index



- History of contact lenses
- The human eye
- Analysis of the eye
- Contact lenses

History



- First designs end of the 19th century
 - Lenses made of glass to correct eye defects
 - Unable to measure the eye exactly
 - Covered the whole eye (scleral lens)
- Uncomfortable



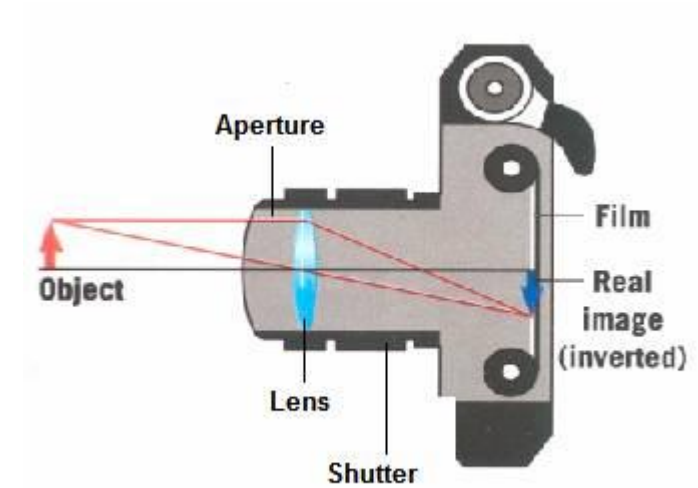
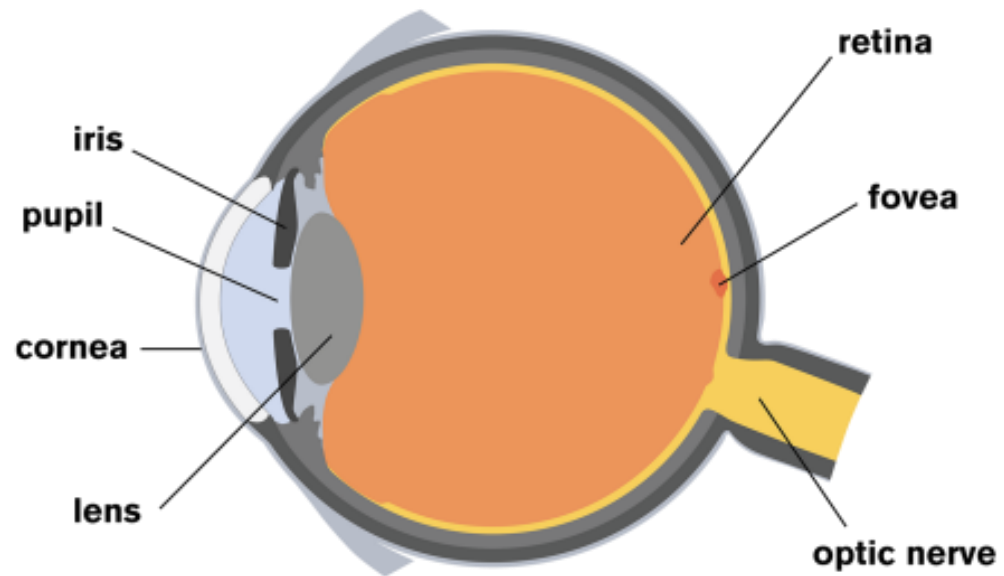
History



- First contact lenses made of acrylic glass at 1945
- Revolution of measuring technologies in 1980
- New design of contact lenses:
 - Corneal contact lenses
- Alternative to glasses
- New challenge for opticians



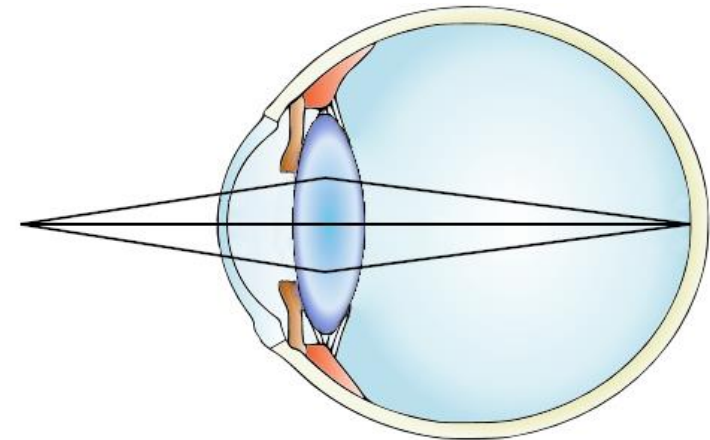
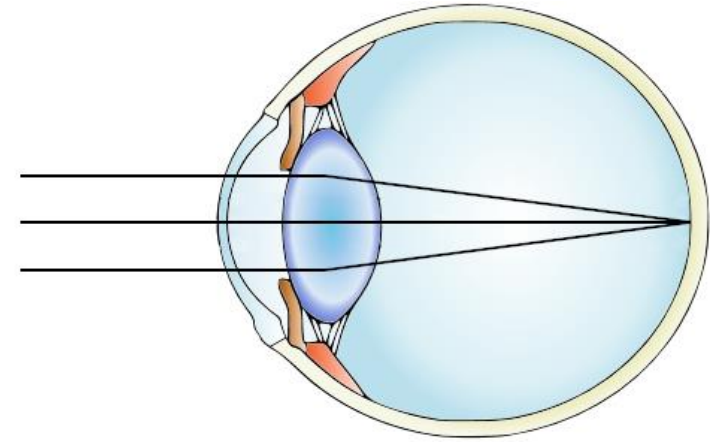
The human eye



The human eye - Accommodation



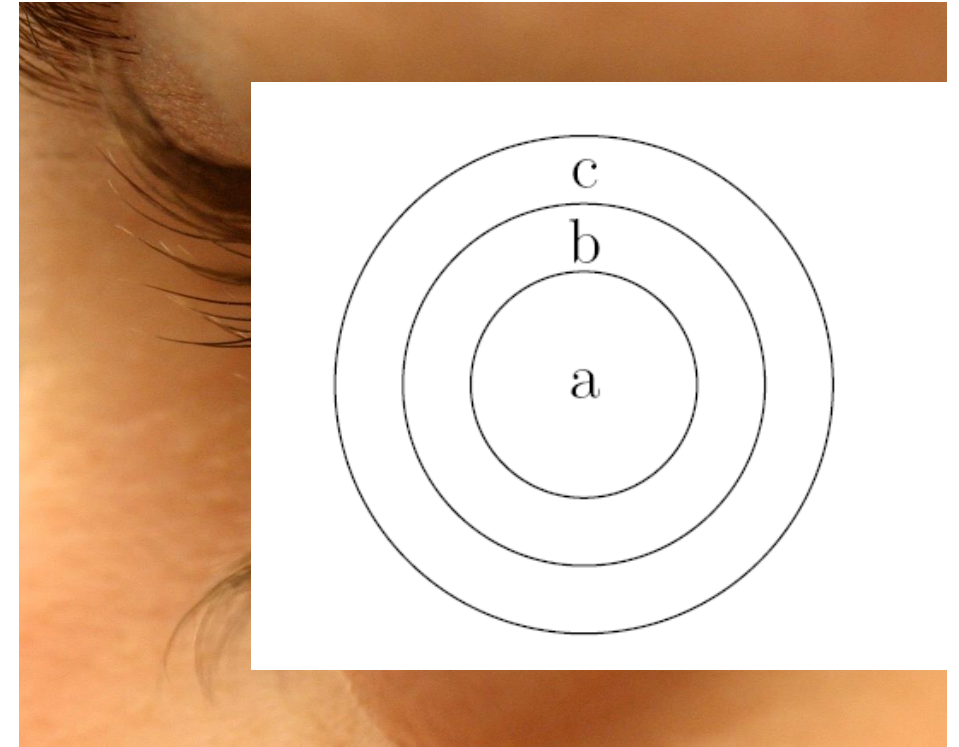
- Different focal length with accommodation
 - Radii change of crystalline lens
- Far object: ciliary muscle is relaxed
- Near objects: ciliary muscle is tensed



The human eye – Front section



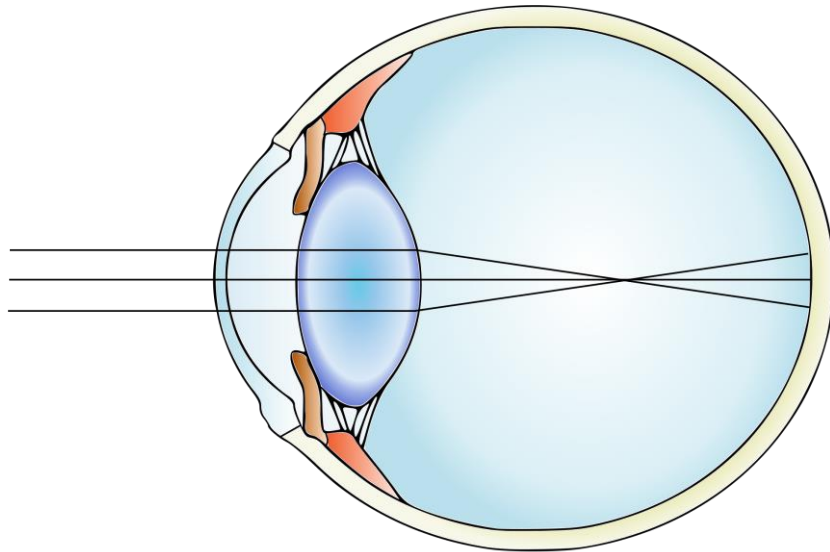
- Cornea
 - Nourishment with oxygen by the tear film
 - Dispose of by-products by the tear film
 - Individually geometry
 - Classical described with a 3-zones Watkins model
 - a) Sphere,
 - b) ellipsoid and
 - c) paraboloid



The human eye – Eye defects



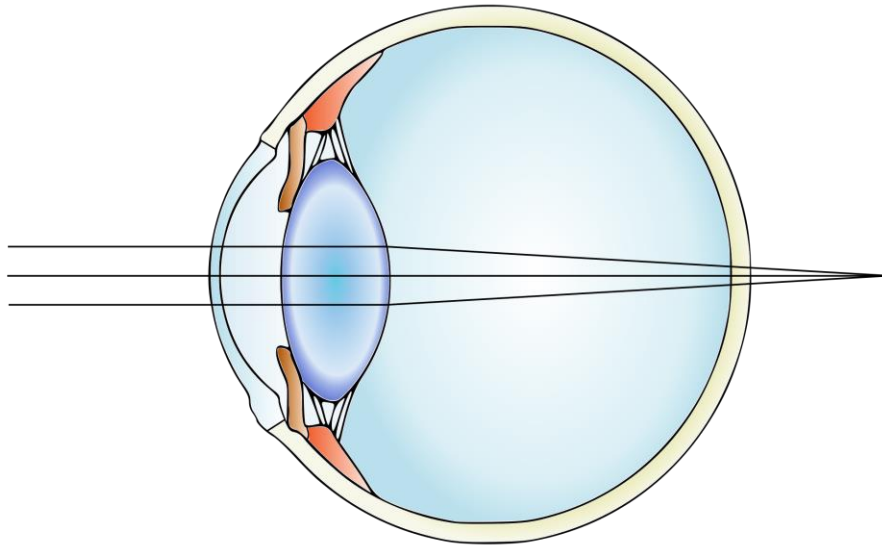
- Myopia (near-sightness)
 - Normally eye is too long
 - Focus in front of the retina
 - Far objects cannot be accommodated



The human eye – Eye defects



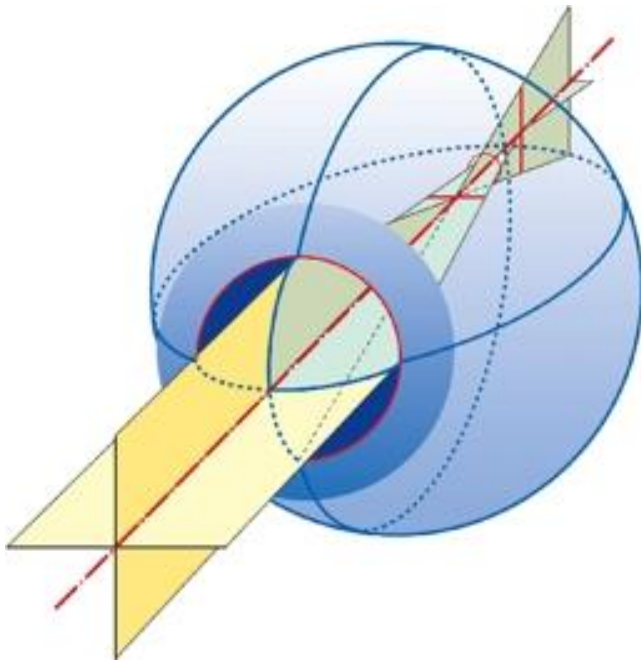
- Hyperopia (far-sightedness)
 - Normally eye is too short
 - Focus behind of the retina
 - Near objects cannot be accommodated



The human eye – Eye defects



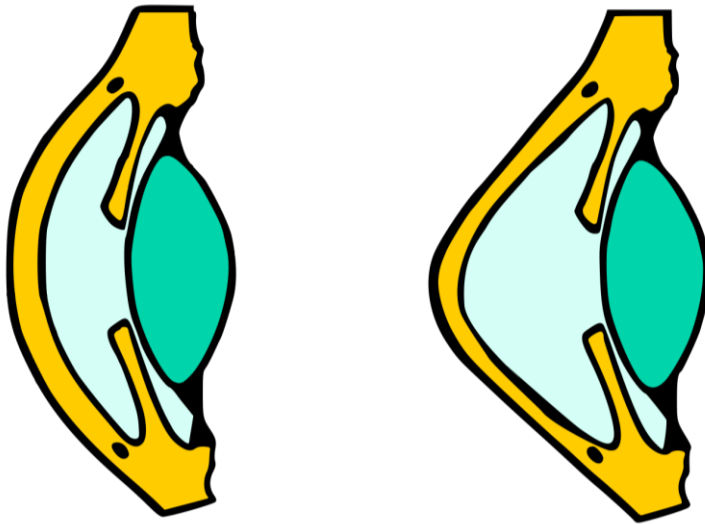
- Astigmatism
 - Toric geometry of the cornea or crystalline lens
 - Different focus in meridians



The human eye – Eye defects



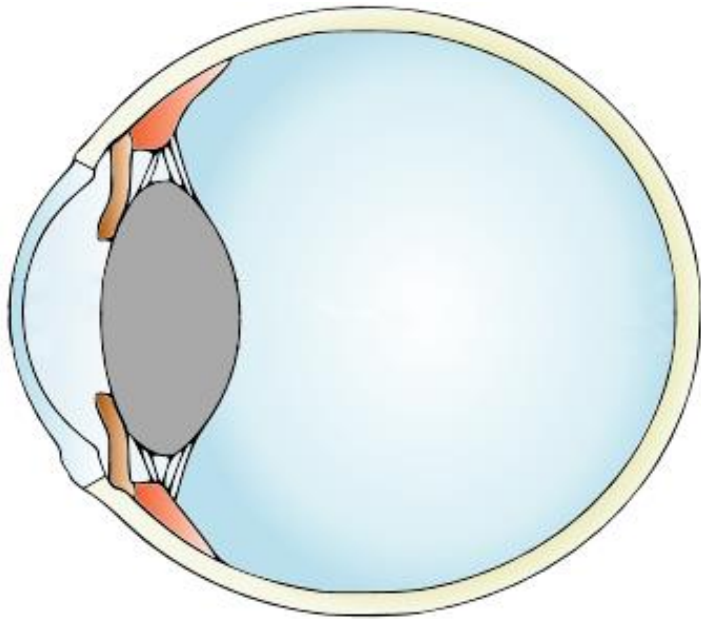
- Special defects, e.g. Keratoconus
 - Highly irregular cornea
 - Distorted image on retina



The human eye – Eye defects



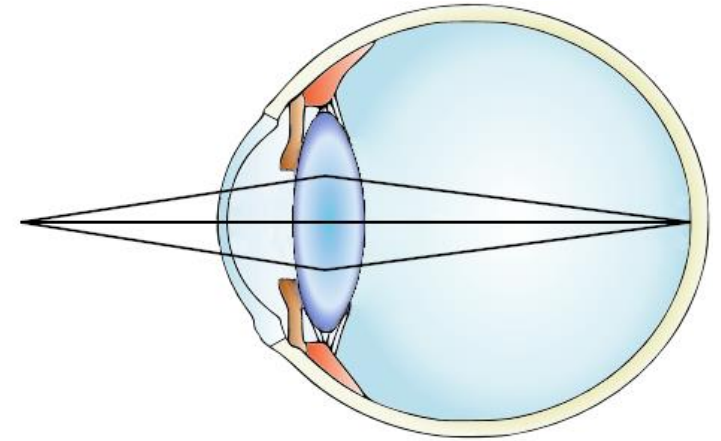
- Cataract
 - Clouding of the crystalline lens
 - Opaque vision



The human eye – Myopia Control



- Myopia increased in the last decades
- Children & young adults with distinctive myopia
- Eye ball is adapting for near objects
 - Eye ball gets longer
 - Stress for the retina
 - Can lead to blindness
- Myopia Control: slow down the myopia process in the eye
- Main caution: View on near objects like Tablet and Smartphone



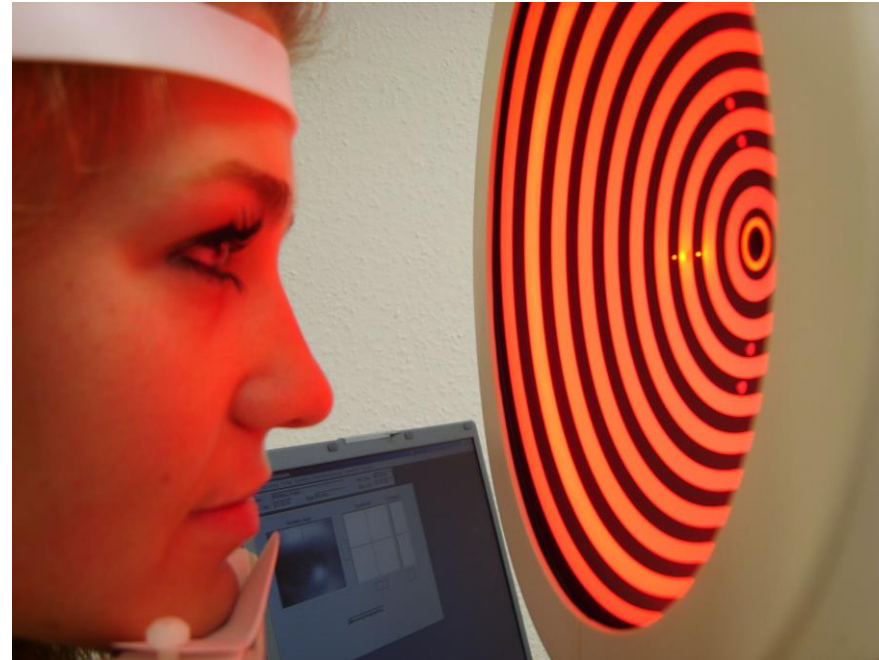
Analysis of the eye



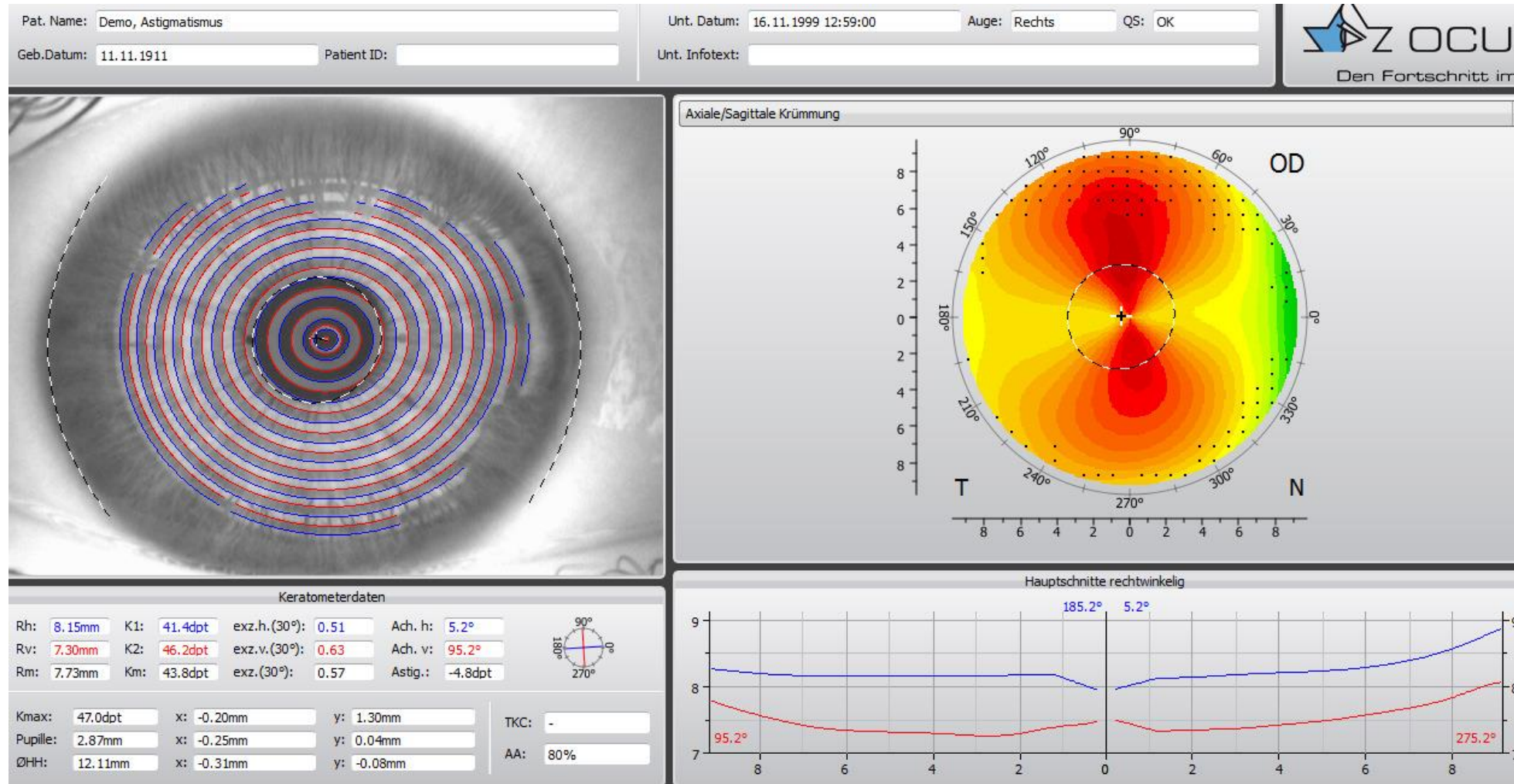
- Purpose:
 1. Determine eye defect
 2. Corneal topography
- Eye defects
 - Manual refraction (subjective)
 - Aberrometry (objective)
- Topography
 - Placido-disk
 - Scheimpflug-principle



Analysis of the eye – Keratograph



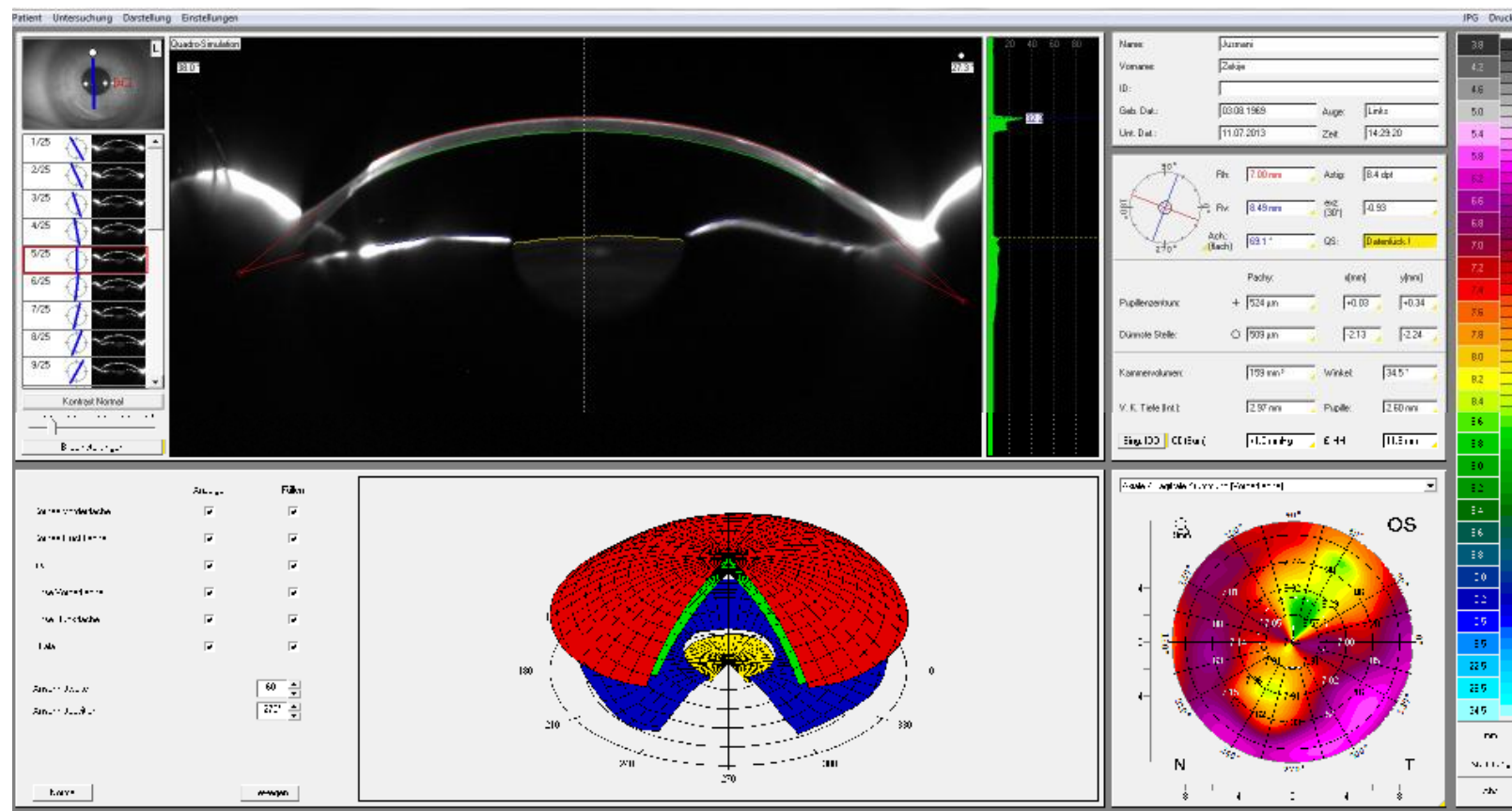
Analysis of the eye – Keratograph



Analysis of the eye – Pentacam

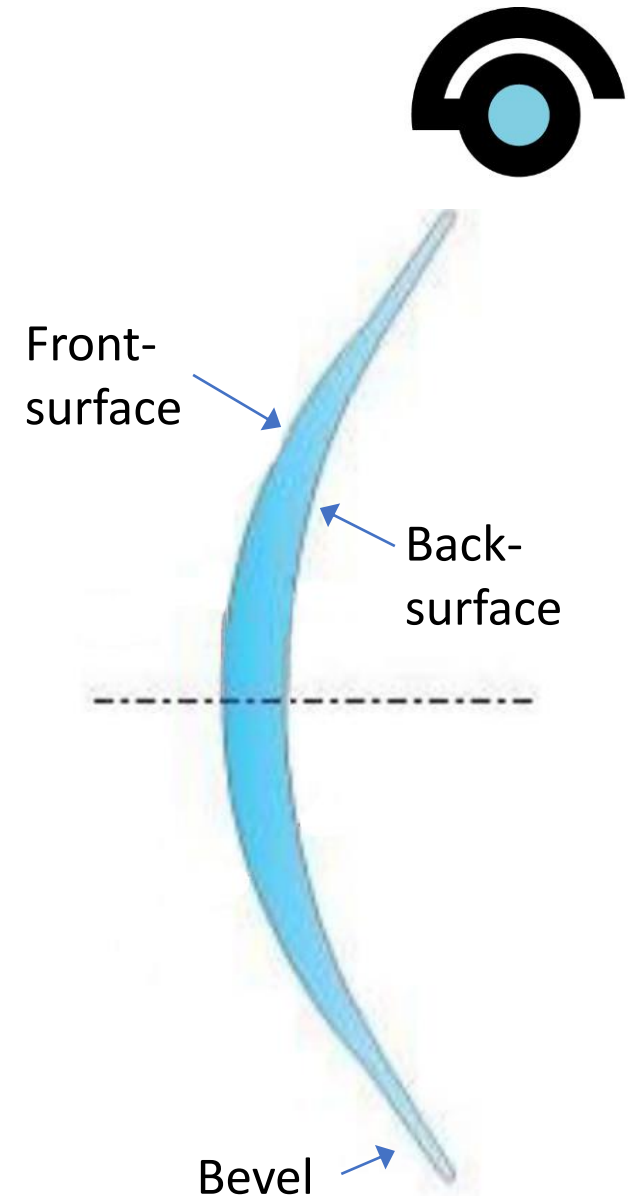


Analysis of the eye – Pentacam



Contact lenses – Setup

- Front- and back surface
- Junction region (bevel)
- Wear comfort is depending on the design of the back surface
- Front surface is mainly used to correct the eye defect
- Different designs for back and front surface



Contact lenses – Parameters



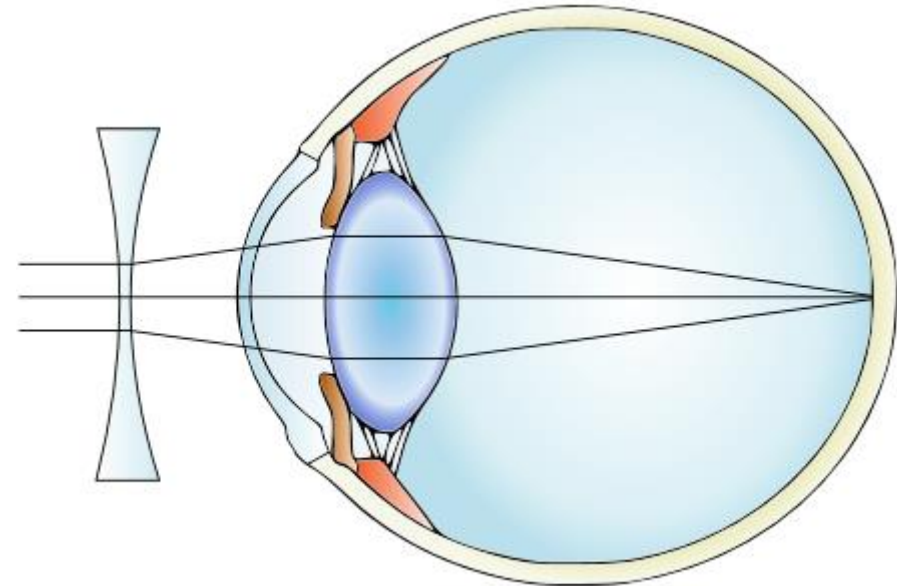
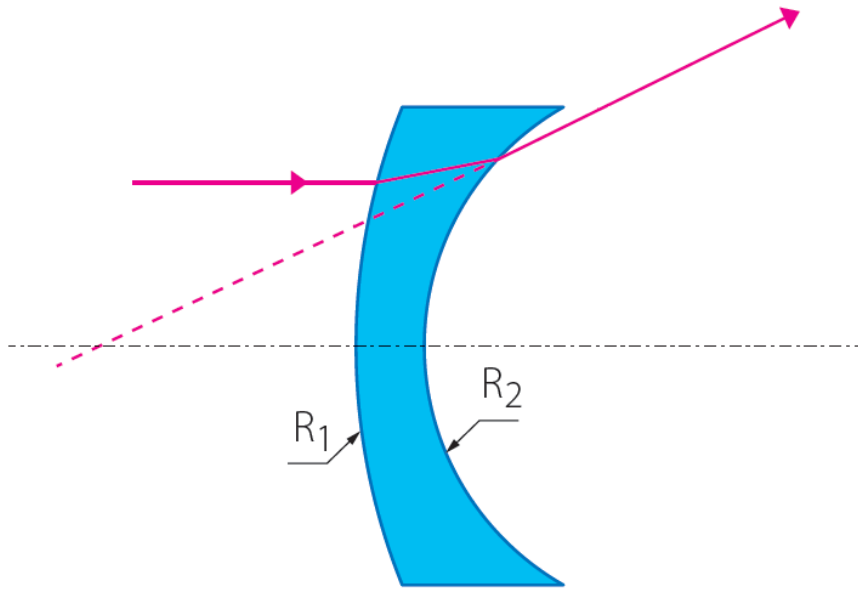
- Base Curve, r0 or BC
 - Describes the radius of the back surface
- Diameter, DIA
 - Diameter of the lens
- Power/Sphere, P or S
 - Optical power of the lens
- Cylinder/Axis
 - For astigmatic eye defects



Contact lenses – Correction



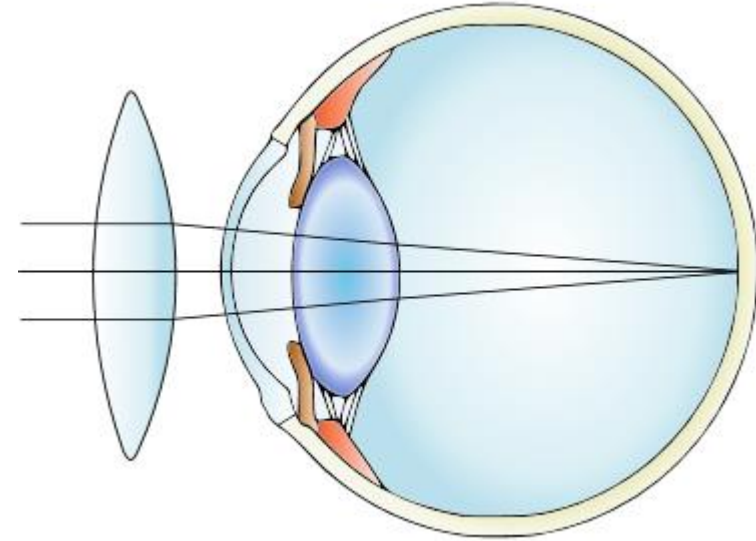
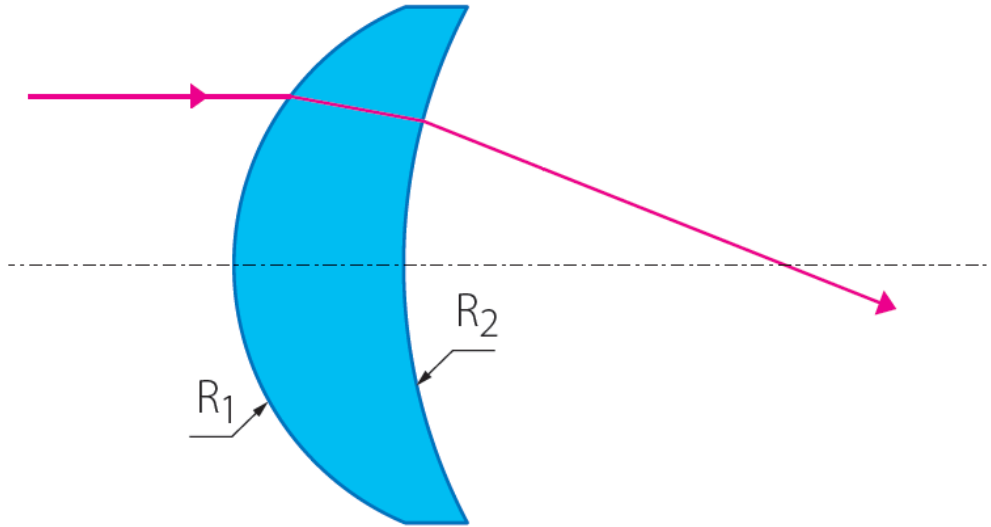
- Myopia
 - Negative meniscus
 - $R_1 > R_2$



Contact lenses – Correction



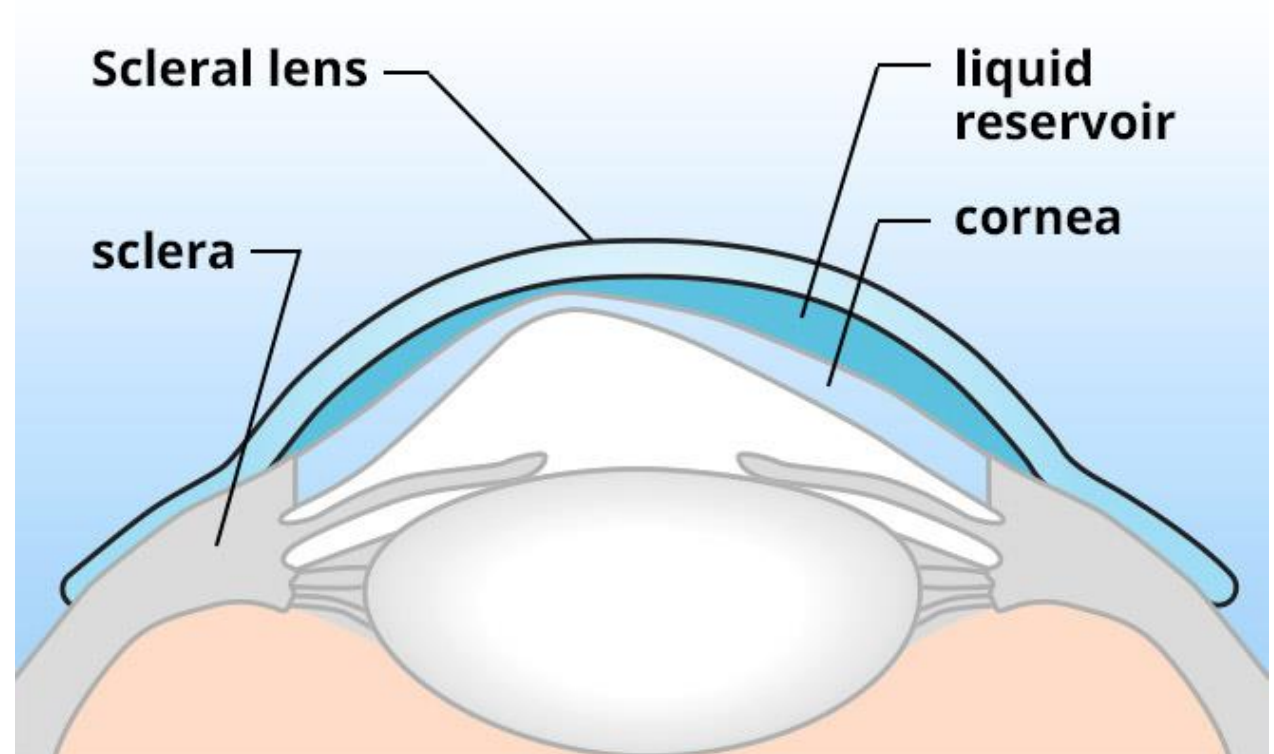
- Hyperopia
 - Positive meniscus
 - $R_1 < R_2$



Contact lenses – Correction



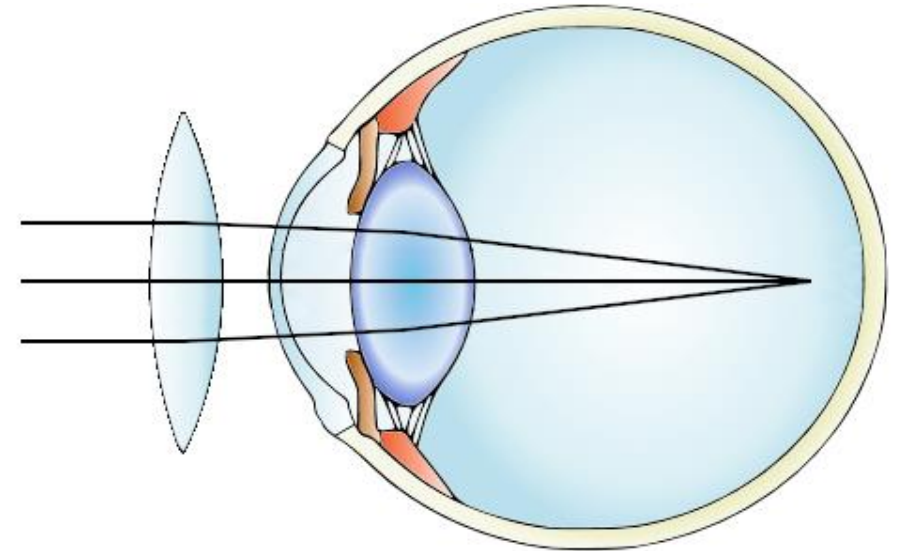
- Astigmatism
 - Specific curvature radius in meridians
- Keratoconus
 - Special contact lens (scleral lens)
 - Reservoir of tear film
 - Tear lens



Contact lenses – Correction



- Myopia Control Prevention:
 - With Contact Lenses: Focal point is in front of the retina → eye ball gets shorter
 - Medicine
- **Best: Go outside!**



Contact lenses – Types



Contact lenses

Corneal lenses

Scleral
lenses

Special
applications

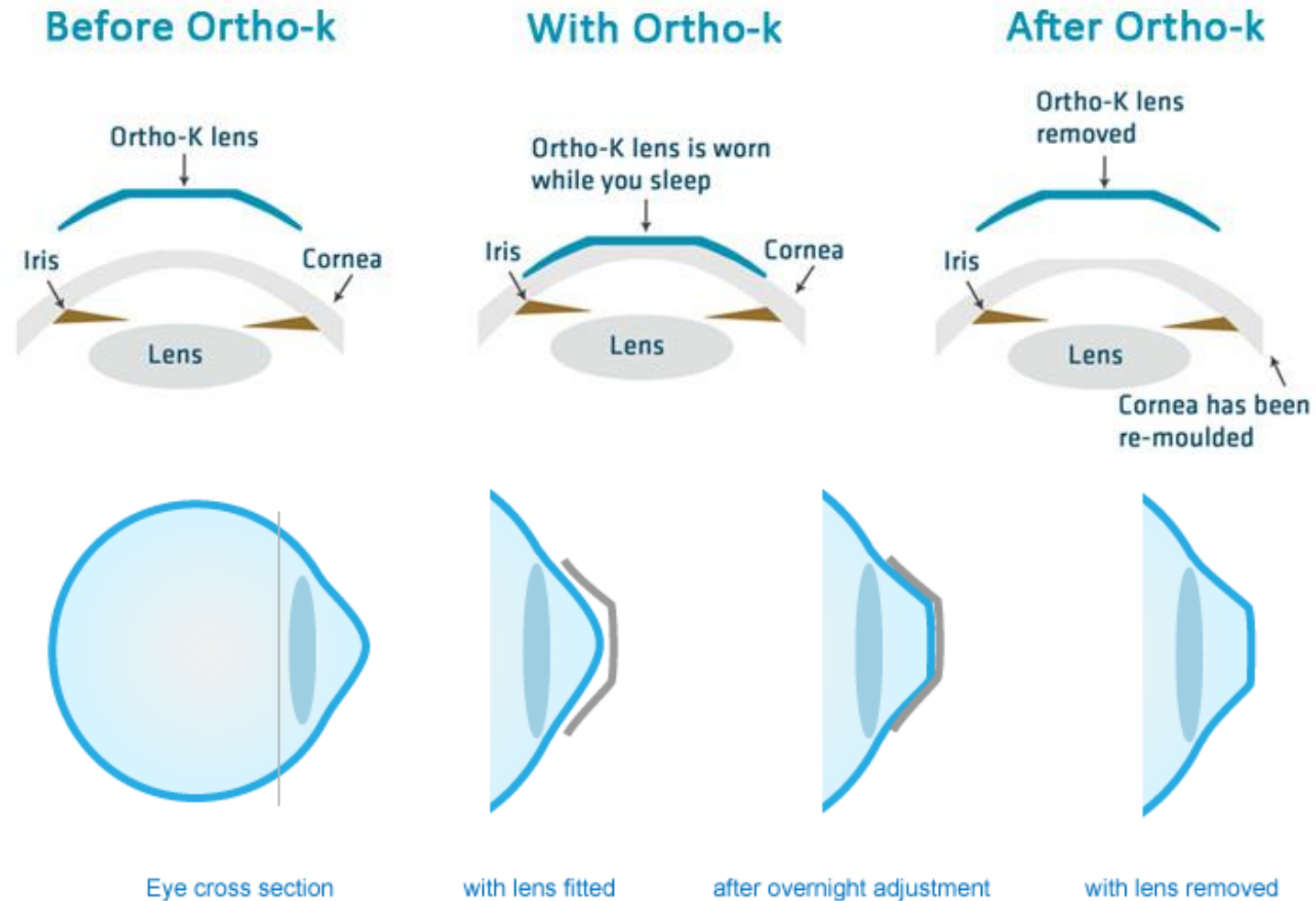
Rigid contact
lenses

Soft contact
lenses

Contact lenses – Special applications



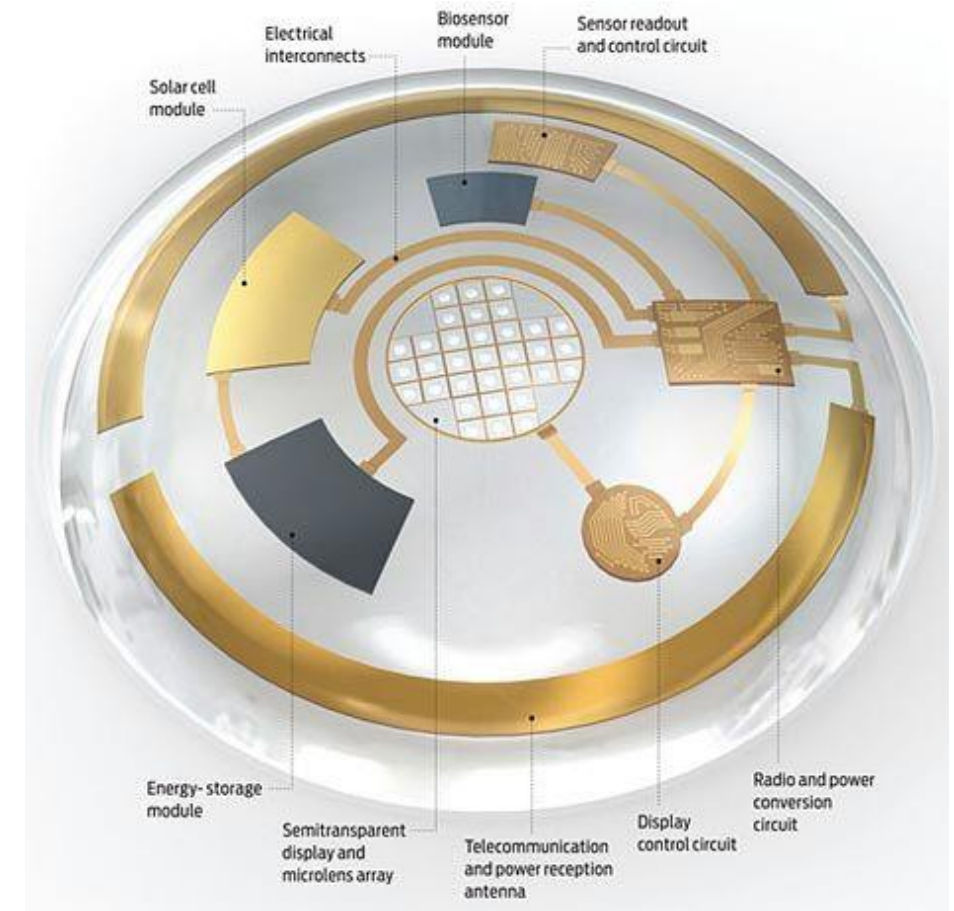
- Ortho-K



Contact lenses – Special applications



- Ortho-K
- Medical applications
- Self-accommodate lenses
- Augment reality



Contact lenses – Scleral lenses



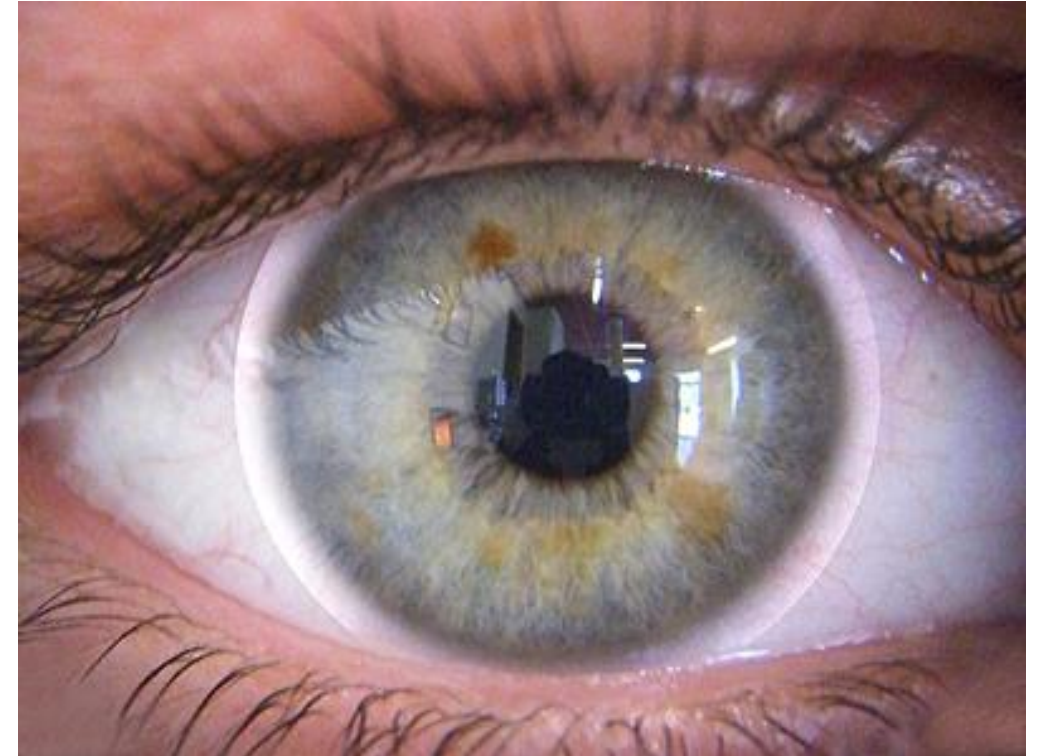
- Covers the whole front section of the eye
- Cornea will not be touched
- Use for high irregular eye defects (e.g. Keratoconus)



Contact lenses – Soft contact lenses



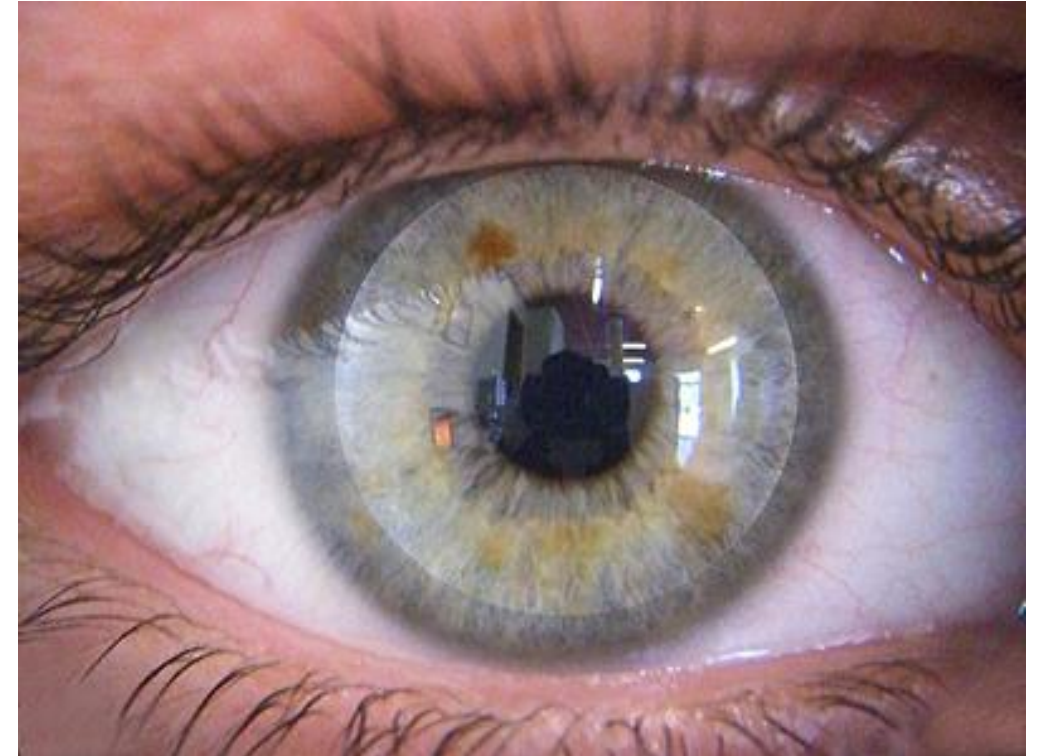
- Direct contact with the cornea
- Covers the whole cornea and parts of the sclera
- Self-fitting to the cornea
- Needs liquid
- Corrects defocus and astigmatism
 - Myopia
 - Hyperopia
 - Astigmatism



Contact lenses – Rigid contact lenses



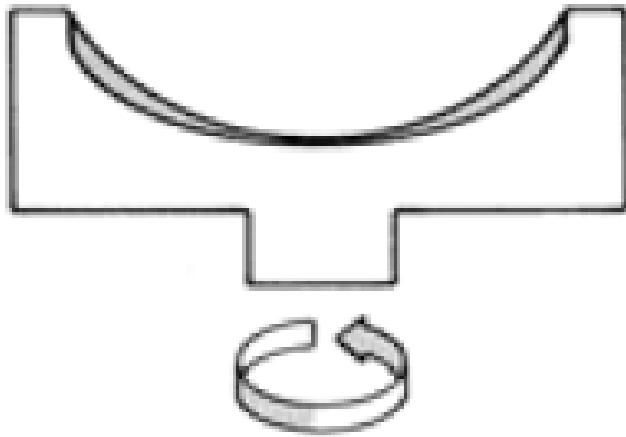
- Direct contact with the cornea
- Covers only parts of the cornea
- Highest permeability of oxygen
- Need to be fitted exactly on the eye
- Corrects defocus and astigmatism
 - Myopia
 - Hyperopia
 - Astigmatism



Contact lenses – Manufacturing



- Different processes
 - Centrifugal casting,
 - Shape casting,
 - Lathe



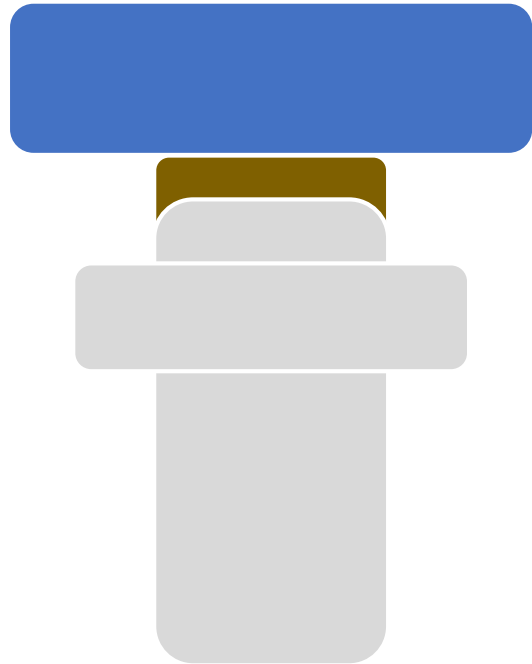
Contact lenses – Material



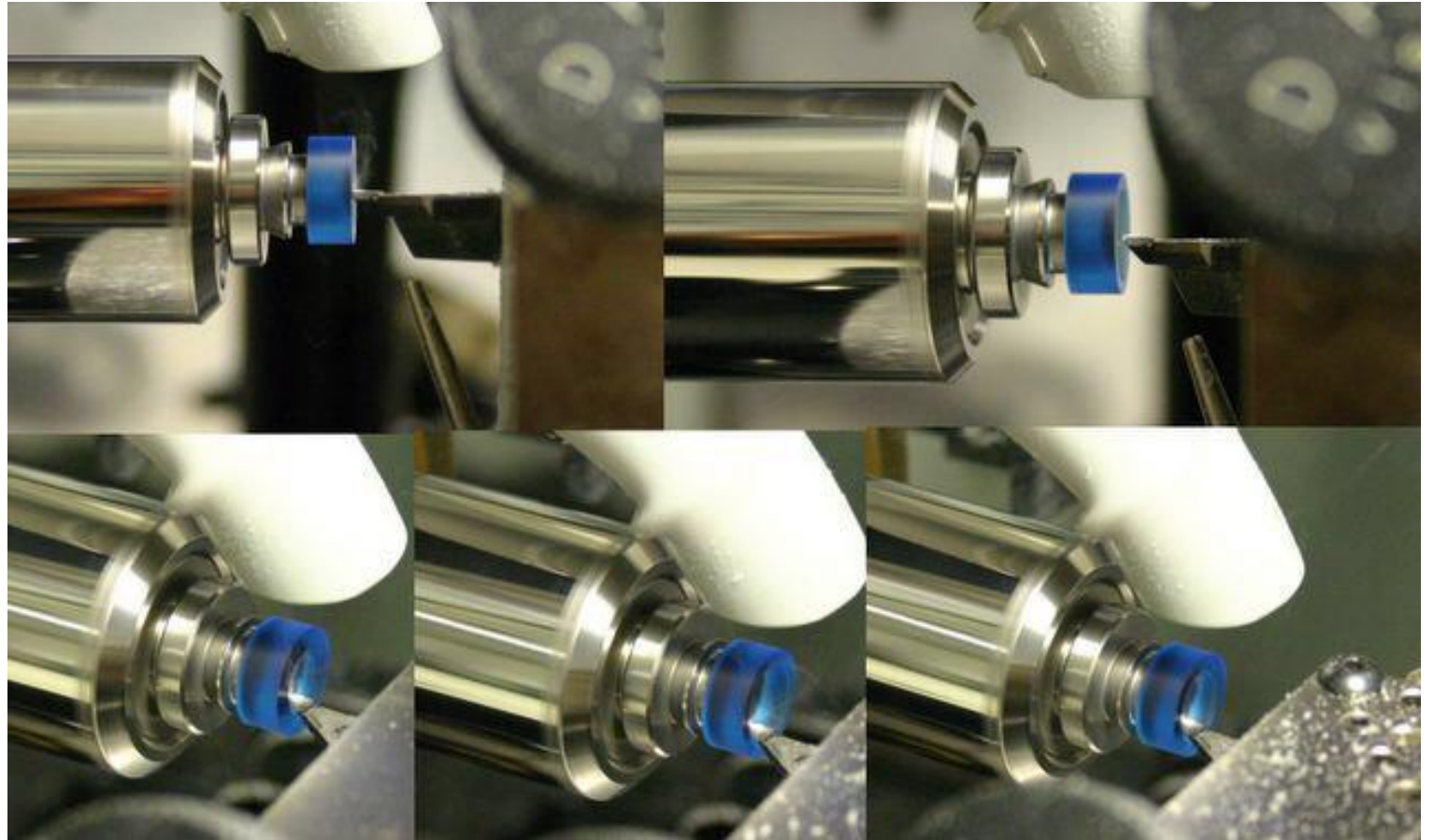
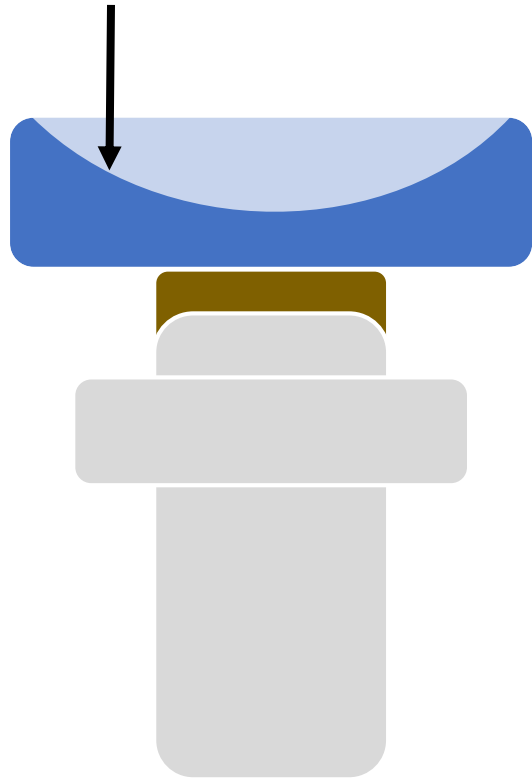
- Blank-cylinder with 12.4 mm diameter and 5 mm thickness
- High quality plastics
 - Fluoric-silicone-acrylic
 - UV filter
 - Oxygen permeability
 - Wettability improvements



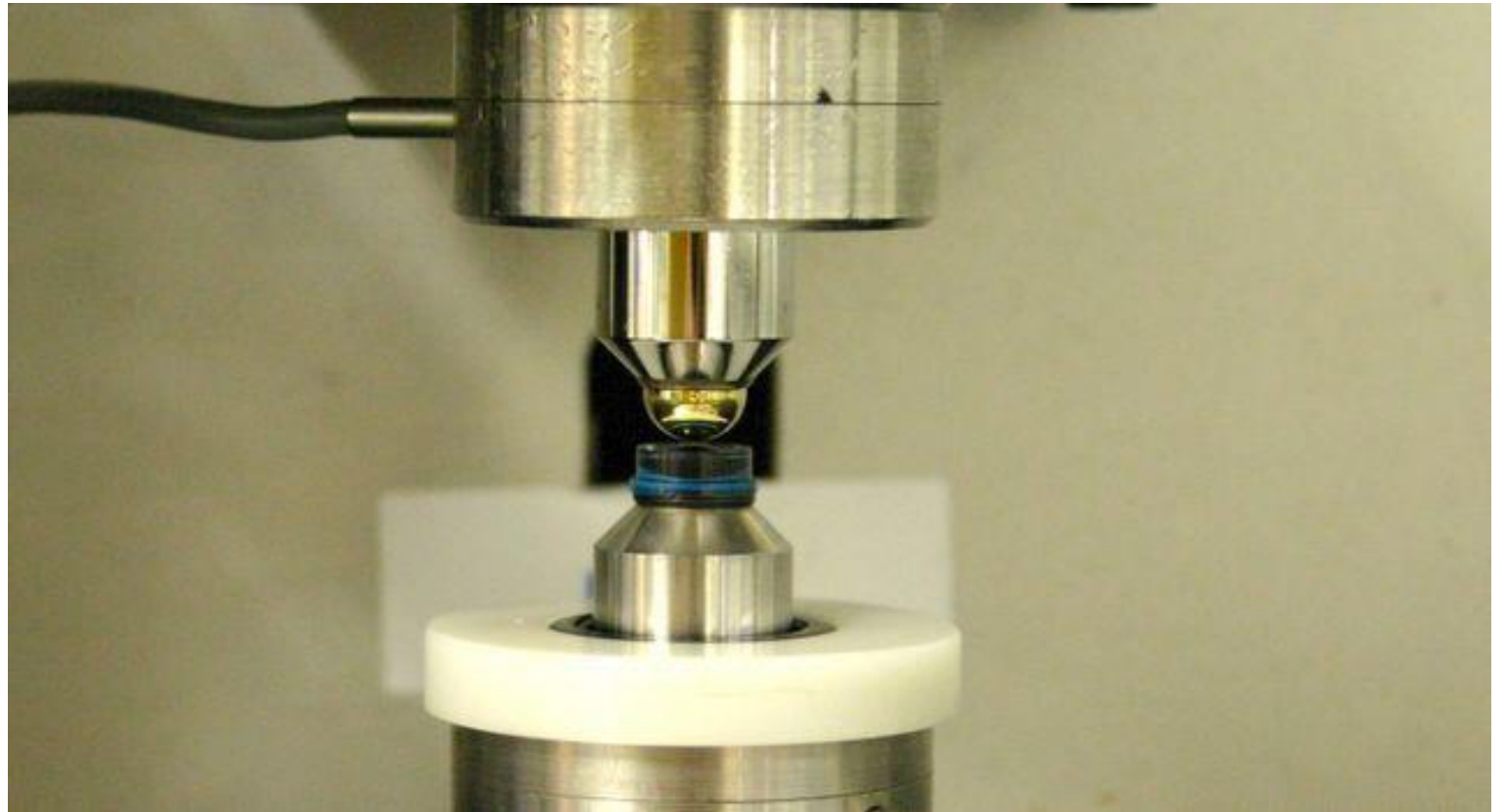
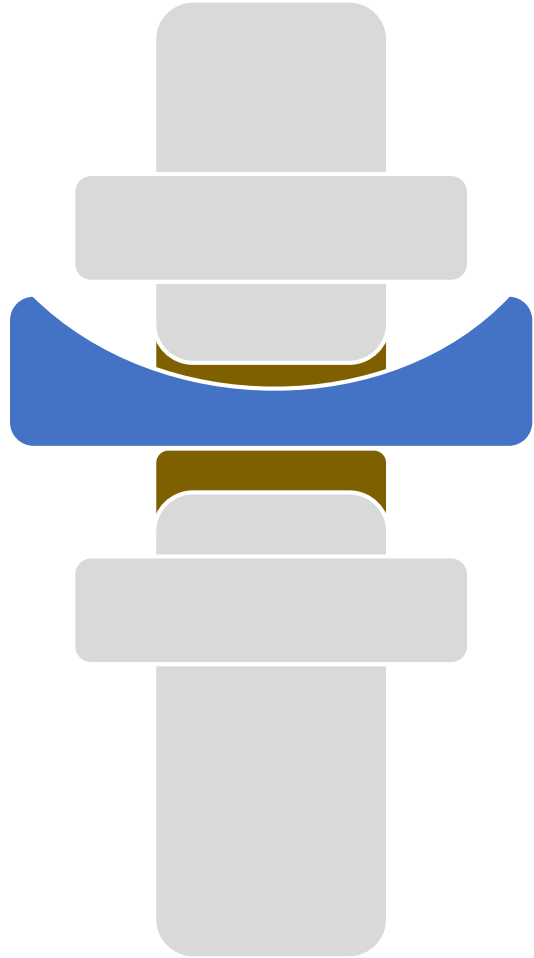
Contact lenses – Start



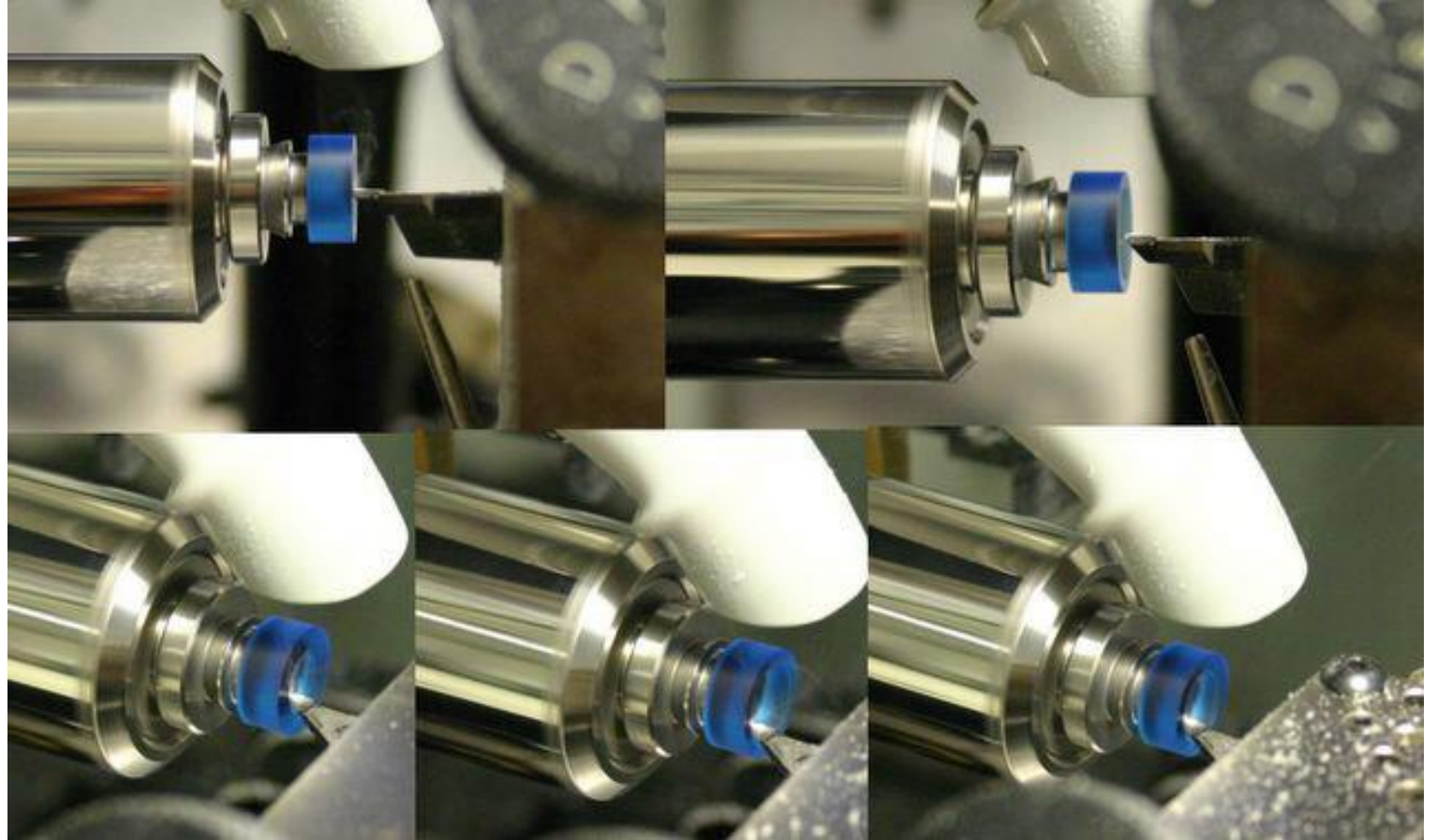
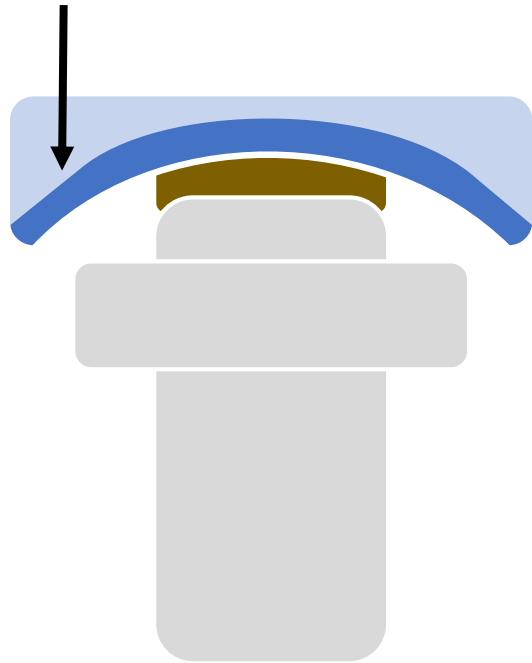
Contact lenses – Lathe back surface



Contact lenses – Switching



Contact lenses – Lathe front surface



Contact lenses – Polishing



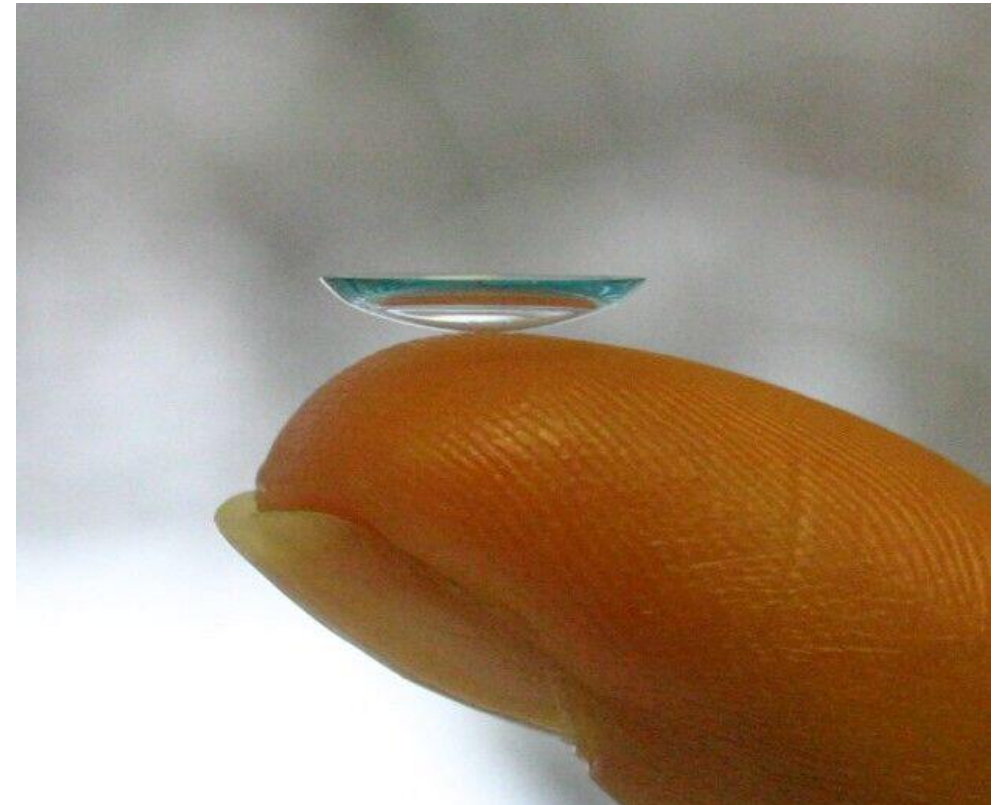
Contact lenses – Inspection



Contact lenses – Final product



- Rotationally and non-rotationally symmetric contact lenses
- Contact lens is only 1% of the blank
- Production process +/- 20 min
- Soft contact lenses
 - Additional step: hydration



Contact lenses – Fitting process



- Cornea is individual like a fingerprint
 - Contact lenses need to be fitted
- Goal is to correct the eye defect with no feeling of the contact lenses
- Different strategies to reach the goal





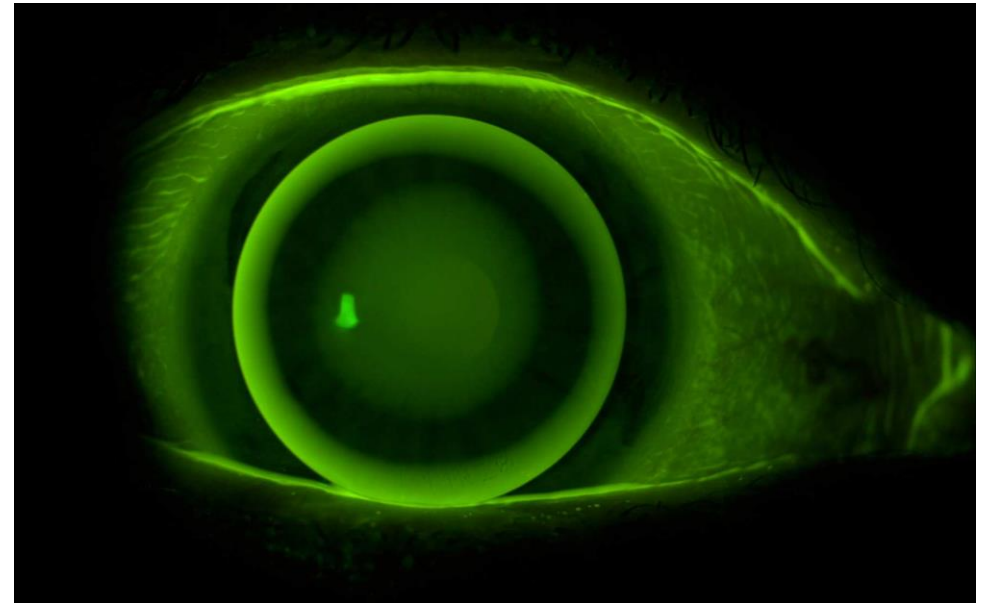
Contact lenses – Fitting process

1. Manual refraction
2. Measuring of the cornea
3. Choose a contact lens design
4. Simulate the fit of the contact lenses on the cornea
 - Dynamic movement of the lenses
5. Testing on the eyes

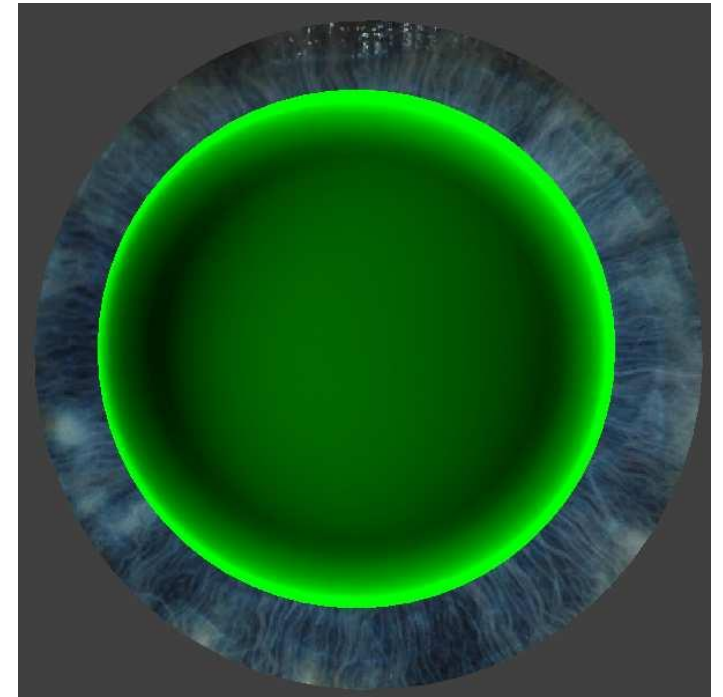
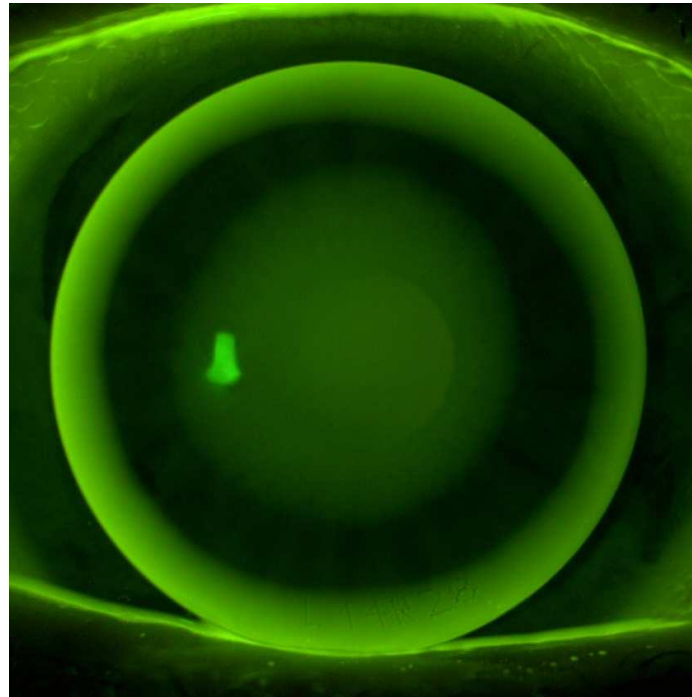
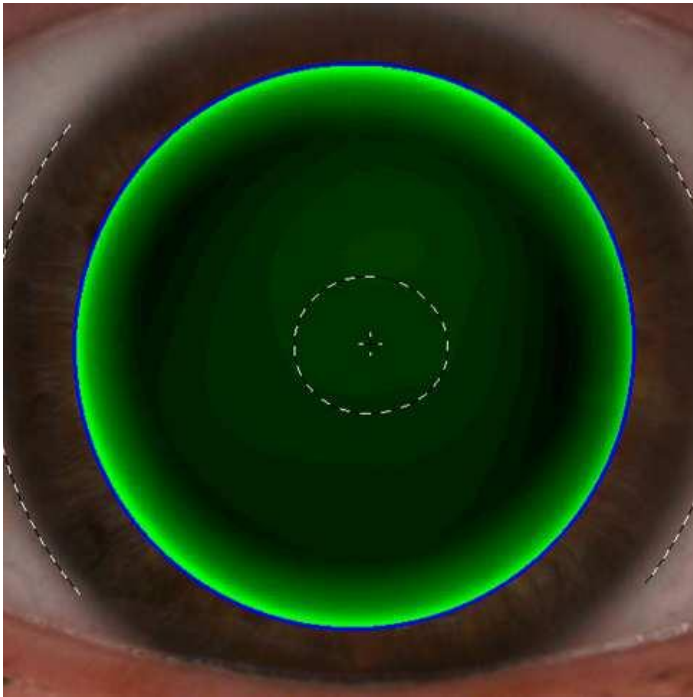
Fitting process – FLUO-test



- FLUO-test is colorized distance between cornea and contact lens
- Dark areas: small distance, brighter areas: larger distance
- Most important test in the fitting process
- Test is simulated in measuring systems



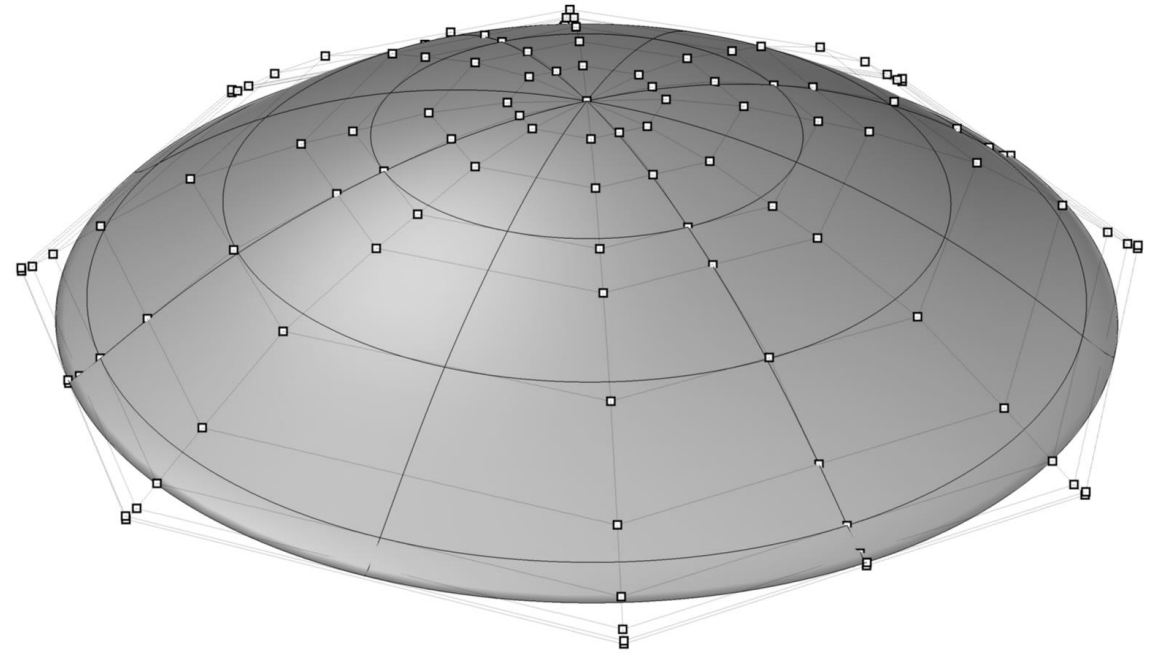
Fitting process – FLUO-test



Contact lenses – Current developments



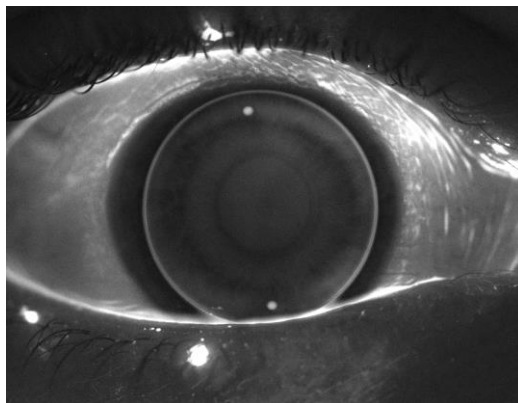
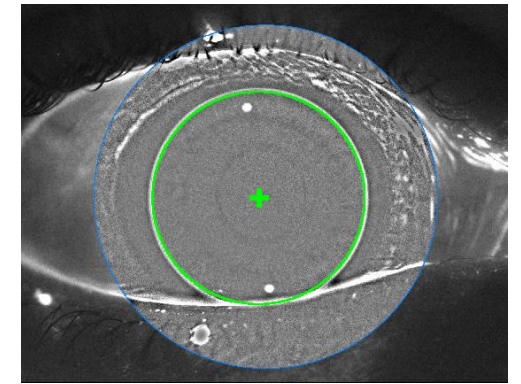
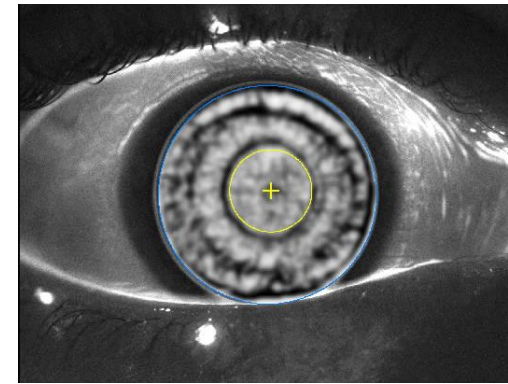
- Correct high order aberrations with rigid contact lenses
- Freeform contact lenses



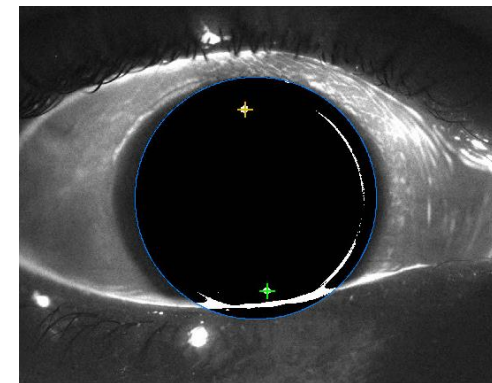
Contact lenses – Current developments



- Contact Lens Tracking System
 - Markers on the lens
 - Displacement and orientation can be analysed automatically
 - Image processing with different filters

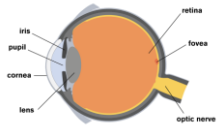


Captured Images

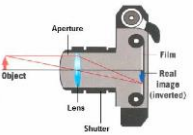


Filtered Images

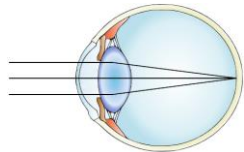
Used figures



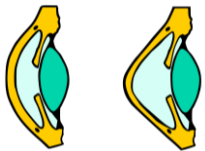
<https://www.tobiipro.com/learn-and-support/learn/eye-tracking-essentials/the-human-eye/>



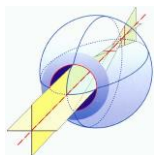
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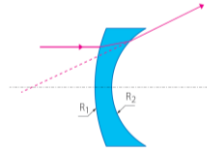
<https://en.wikipedia.org/wiki/Near-sightedness>



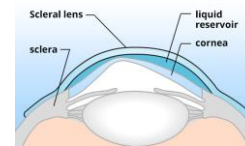
<https://www.eyewise.com/eye-care-services-roslyn-manhattan/keratoconus-treatment-in-roslyn-and-manhattan/>



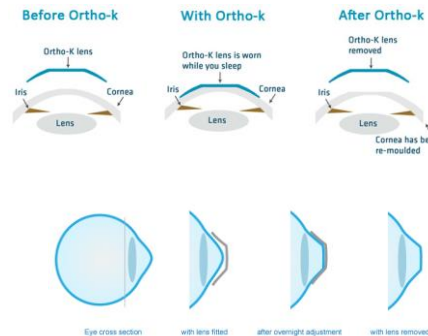
<https://www.uni-due.de/~tah0f0/Excimer/Frames/Stabsichtigkeit.html>



http://www.altechna.de/product_details.php?id=56



<https://www.drvisionworld.com/scleral-lenses/>



<https://www.goldenvisionoptometry.net/ortho-k-center.html>

Thank you for your attention