HEIDELBERG UNIVERSITY HOSPITAL

UNIVERSITY EYE CLINIC 150 Years

DAVID J APPLE LABORATORY

IVCRC.net International Vision Correction Research Center Network

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How to evaluate IOL Injectors in the David J. Apple International Laboratory for Ocular Pathology

Gerd U. Auffarth

International Vision Correction Research Centre (IVCRC)
The David J. Apple International Laboratory for Ocular Pathology
Department of Ophthalmology
Ruprecht-Karls-University of Heidelberg
Chairman: G. U. Auffarth, MD, PhD, FEBO, FWCRS

UK HD

IVCRC / DJ Apple Laboratory: Financial Disclosure 2025/2026

Afidera[3]
Alcon[1,2,3,4]
AMO/Johnson&Johnson[1,2,3,4]
Carl Zeiss Meditec[1,2,3,4]
Contamac[1]
Cristalens[1,2,3,4]
Elios[1,3,4]
Eyebright[3]
EyeD[1]
Eyedeal[1]
EyeYon[1,2,4]
Fluoron[1]
Hanita[1,2,3,4]
Hoya[1,2,3]
Kowa[1,2,3]
Oculus[1,3]
Presbia[1]
Rayner[1,2,3,4]
Teleon[1,2,3]
1stQ[1]

Ernst und Berta Grimmke-Stiftung

Baden-Württemberg Stiftung

JOACHIM HERZ STIFTUNG

Hans und Ria Messer Stiftung

Bundesministerium für Bildung und Forschung

HEiKA Heidelberg Karlsruhe Research Partnership

MEDIZINISCHE FAKULTÄT HEIDELBERG

Klaus Tschira Stiftung Gemeinnützige GmbH KTS

DIETMAR HOPP STIFTUNG

1 = Research Grants; 2 = Travel Expenses; 3 = Lecture Fees; 4 = Consulting

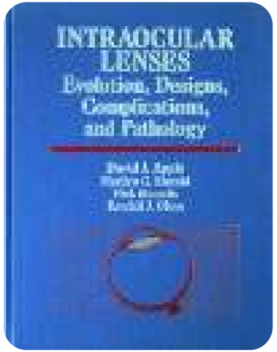
David J. Apple MD (1941-2011)

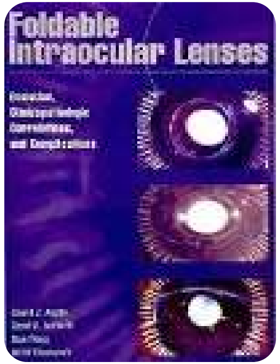
Pioneer of the intraocular lens pathology

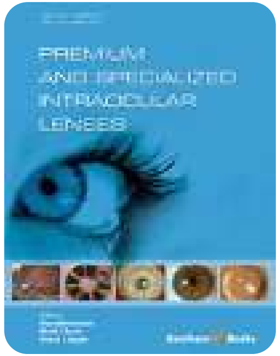
Laboratory in the USA : 1980-2011

(Salt Lake City/Charleston)

Laboratory relocation to Heidelberg: 2012







Examination techniques developed in the D. J. Apple laboratory

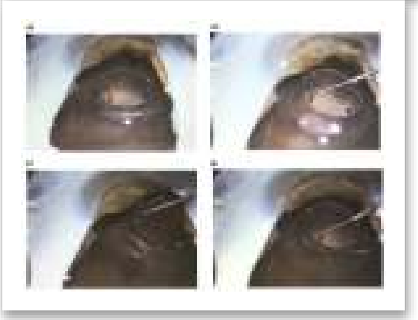
Preparation and Study of Human Eyes Obtained Postmortem with the Miyake Posterior Photographic Technique

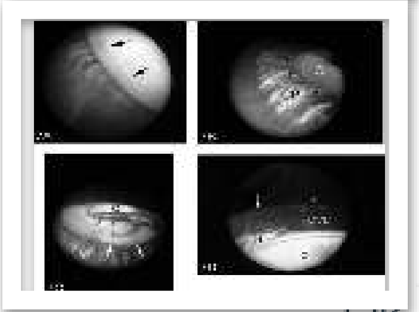
Photoanalysis of Fixation of Posterior Chamber Intraocular Lenses

A Modified Preparation Technique for Closed-system Ocular Surgery of Human Eyes Obtained Postmortem

An Improved Research and Teaching Tool

New Endoscopic Technique to Analyze Various Modern Specialized Intraocular Lenses in Research Eyes and Human Eyes Obtained Postmortem





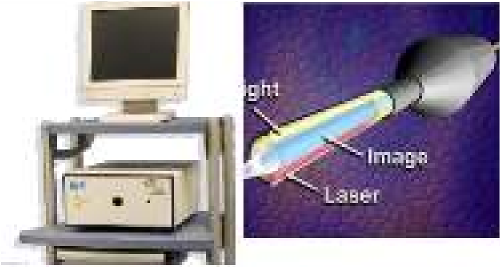
New developments in the David J. Apple laboratory in HD

CLAREON Autonome

high speed camera

(Special setup for D.J.Apple Laboratory)
1.3 M Pixel image resolution up to 6.000fps
900x700 Pixel Image resolution up to 20.000fps
300x230 Pixel Image resolution up to 100.000fps
Gigabit Ethernet interface
Auto Exposure control

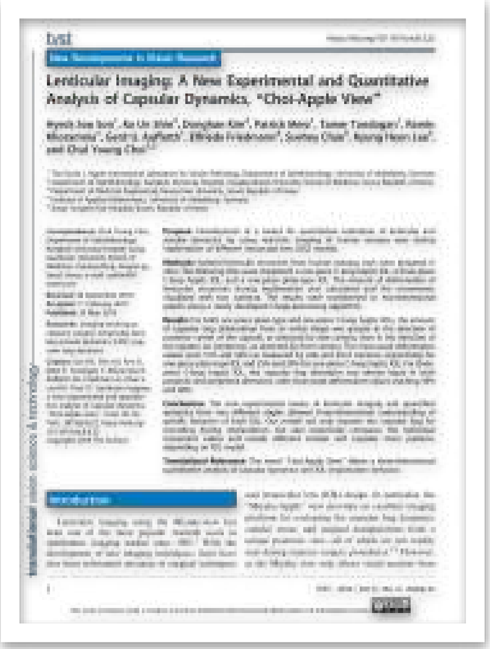
CLAREON Autonome



intraocular endoscope

New developments in the David J. Apple laboratory in HD

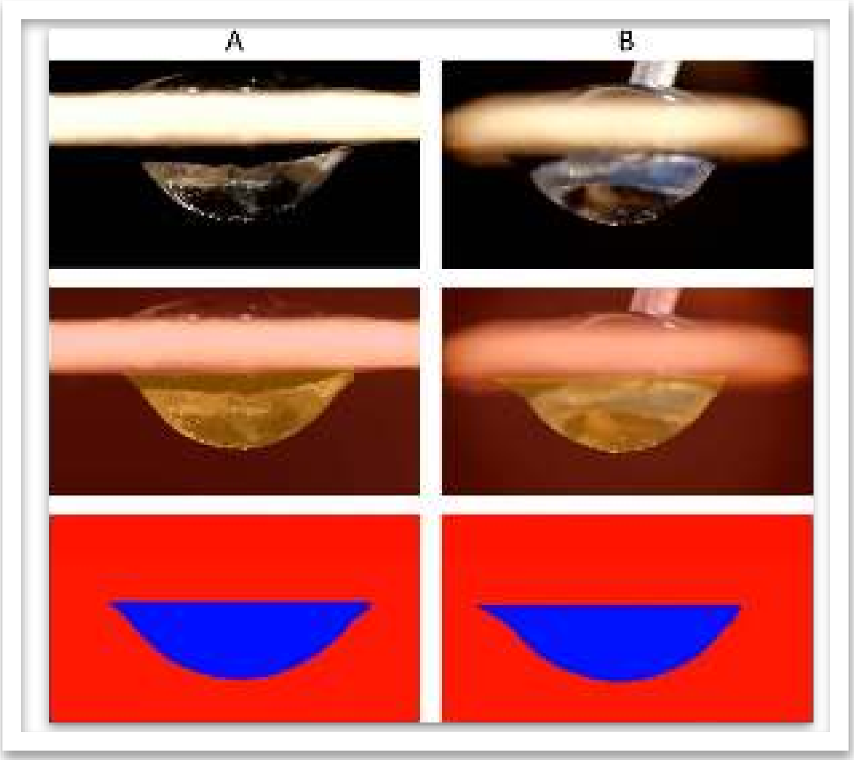
„Apple-Choi-Side View“*


tvst

New Developments in Vision Research

Lenticular Imaging: A New Experimental and Quantitative Analysis of Capsular Dynamics, "Choi-Apple View"

Introduction



*Son HS, Shin KU, Kim D, Merz P, Tandogan T, Khoramnia R, Auffarth GU, Friedmann E, Chae S, Lee KH, Choi CY. Lenticular imaging: a new experimental and quantitative analysis of capsular dynamics, ''Choi-Apple view''. Trans Vis Sci Tech. 2019;8(3):22, https://doi.org/ 10.1167/tvst.8.3.22

Analysis methods for injector systems

- Static examination methods
  - Light microscopy
  - Scanning electron microscopy
  - Physical optical measurements

- Dynamic examination methods
  - „Miyake-Apple Posterior View“
  - „Endoscopic View“
  - „High-speed" camera analyses
  - „Apple-Choi Side View“

Static examination methods

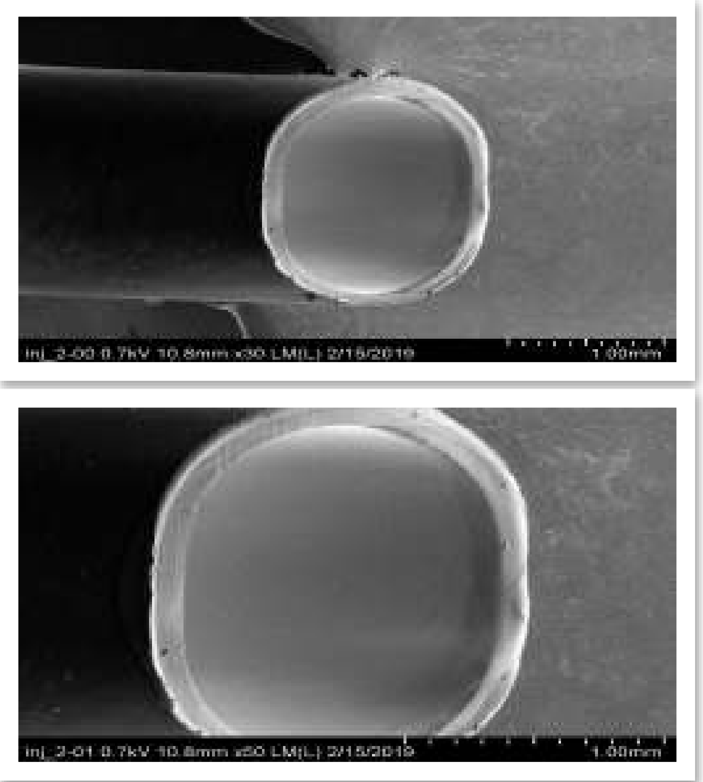
Scanning electron microscopic examination of the injector cartridges

DAVID J APPLE LABORATORY

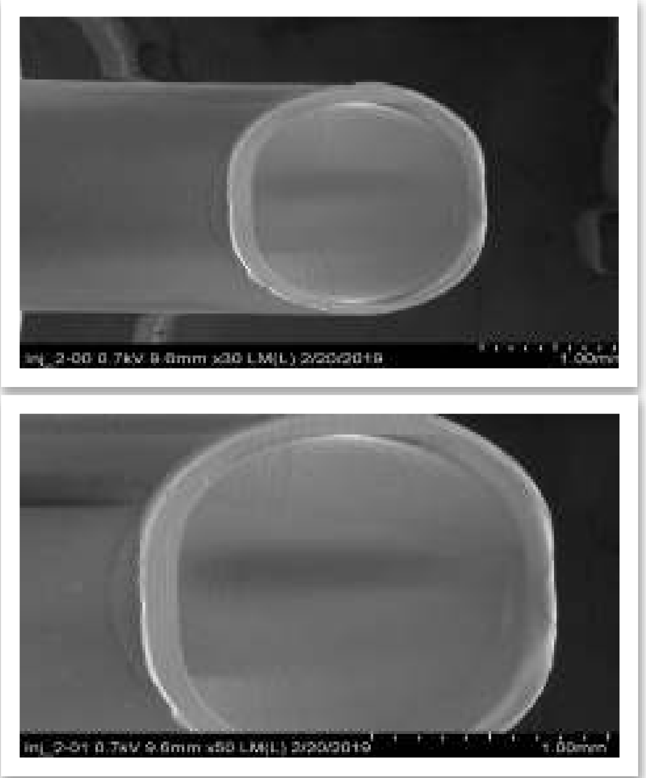
MAX-PLANCK-INSTITUT FÜR POLYMERFORSCHUNG

SEM Study on Injector Cartridge Damage*

Clareon Autonome



before implantation

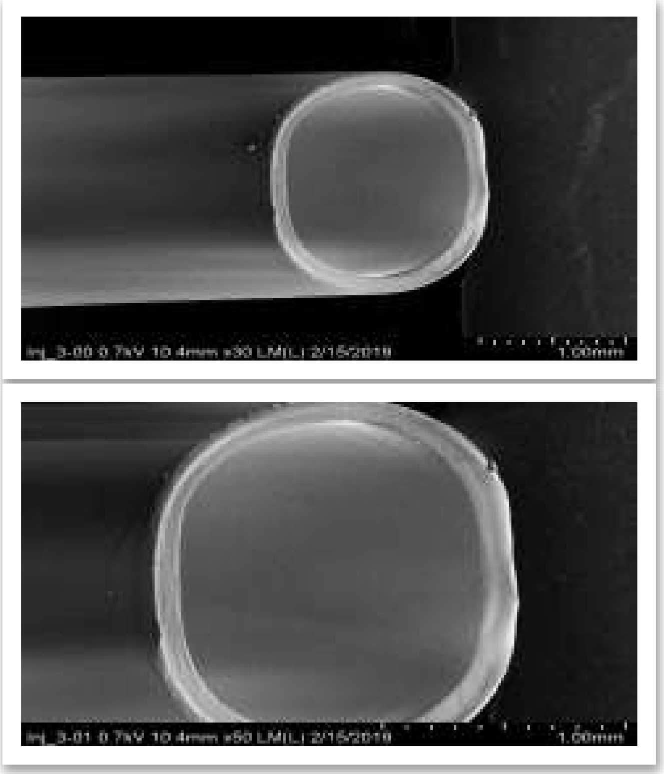


after implantation

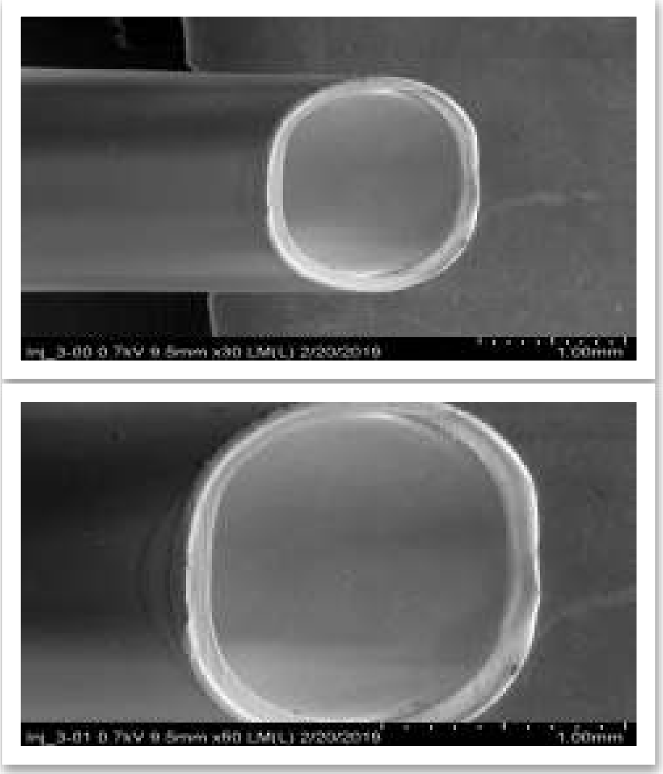
*Data on file: David J Apple International Laboratory for Ocular Pathology, University Eye Clinic Heidelberg, Germany

SEM Study on Injector Cartridge Damage*

Clareon
Autonome



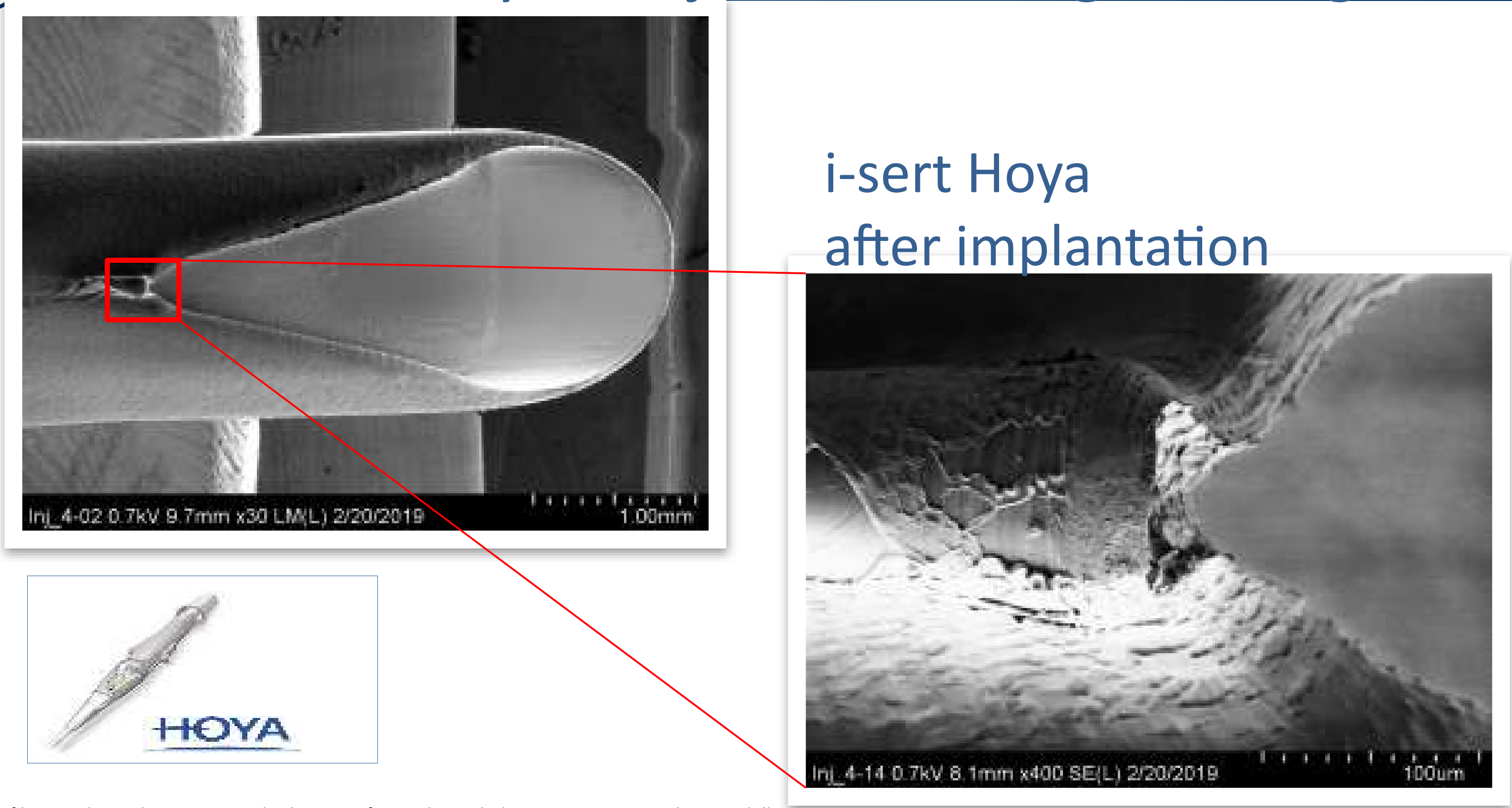
before implantation



after implantation

*Data on file: David J Apple International Laboratory for Ocular Pathology, University Eye Clinic Heidelberg, Germany

SEM Study on Injector Cartridge Damage*

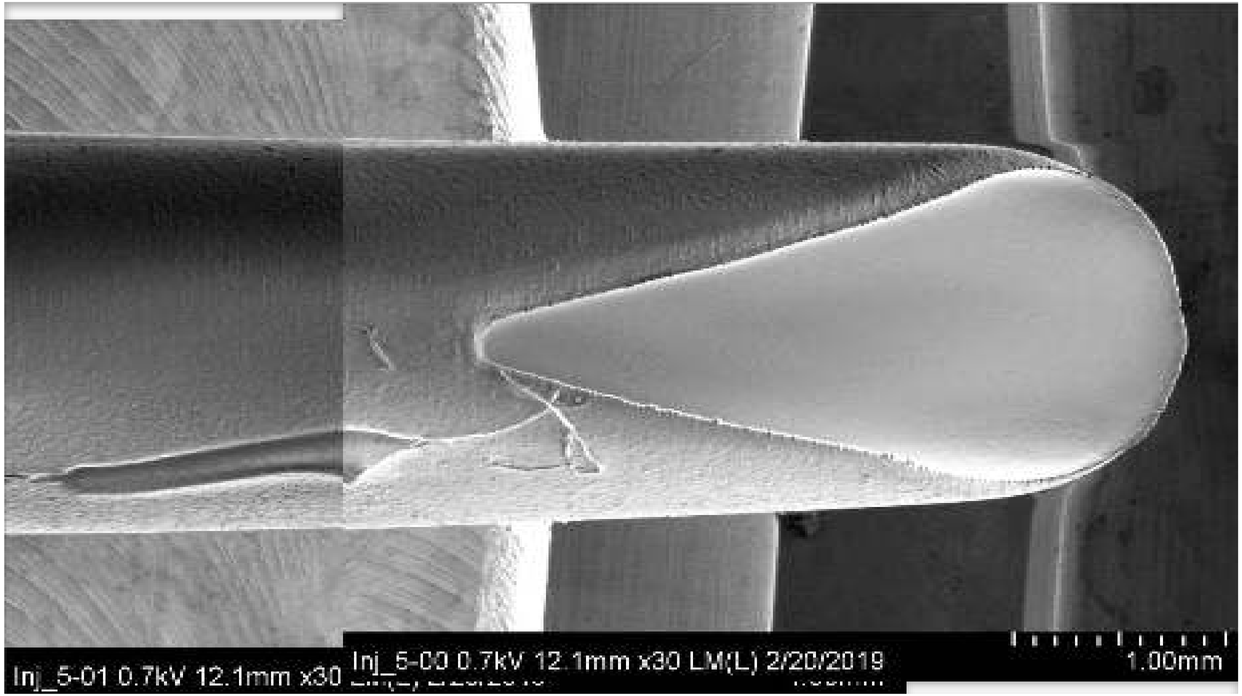


i-sert Hoya
after implantation

*Data on file: David J Apple International Laboratory for Ocular Pathology, University Eye Clinic Heidelberg, Germany

SEM Study on Injector Cartridge Damage*

i-sert Hoya
after implantation



*Data on file: David J Apple International Laboratory for Ocular Pathology, University Eye Clinic Heidelberg, Germany

Static examination methods

Heidelberg light microscopy damage category scheme for injector cartridges

Materials and Methods*

Microscope: Olympus BX50

Injectors:148

- 148 injectors with different refractive power from 9 preloaded and manually-loaded systems were collected after implantation in cataract surgery.
- The damage on the injectors was observed and graded under microscope. Pictures of the damage were taken.
- The damage scores of the injectors were compared within the same system and among different systems.

Table 1: data of different injector systems

Company	*Injector*	*Number*
Alcon	UltraSert	16
AMO	Sensar	12
ZEISS	ACCUJECT	15
HOYA	iSert	21
AMO	TECNIS iTec	30
Rayner	RaySert Plus	7
SIFI	Miniwell Ready	17
Alcon	MONARCH III Cartridge	15
Alcon	AcrySert	15
Sum		148

Table 2: damage degree of injectors and corresponding grades

Damage Degree	Grade	Damage score
No damages	0	-1
Slight scratches	1	1
Significant scratches	2	2
Extensions	3	3
Slight cracks	4	4
Significant cracks and burst	5	5

*Data on file: David J. Apple International Laboratory for Ocular Pathology, Dept. of Ophthalmology, University-Eye-Clinic Heidelberg

Damage categories (Heidelberger Scheme)

no damage

slight scratches

deep scratches

extensions

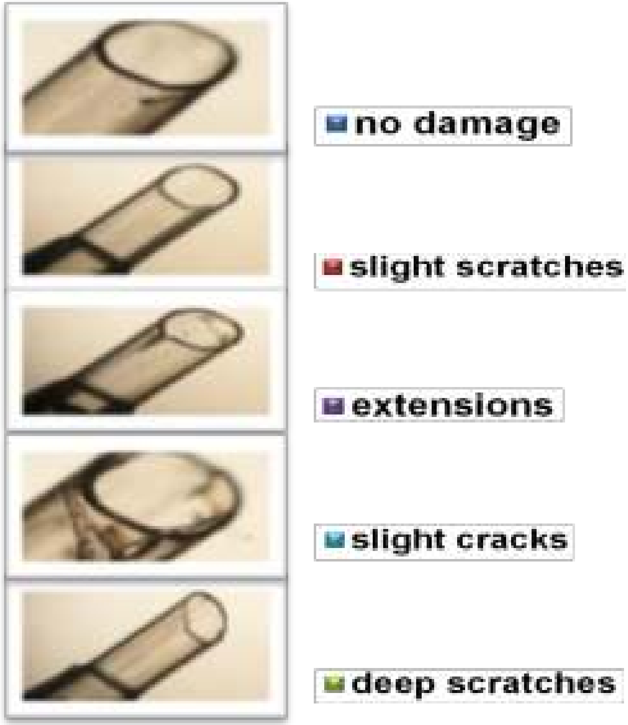
slight cracks

cracks and burst

*Data on file: David J. Apple International Laboratory for Ocular Pathology, Dept. of Ophthalmology, University-Eye-Clinic Heidelberg

Alcon AcrySert injector system*

*hydrophobic IOL material



*Data on file: David J. Apple International Laboratory for Ocular Pathology, Dept. of Ophthalmology, University-Eye-Clinic Heidelberg

Alcon UltraSert injector system*

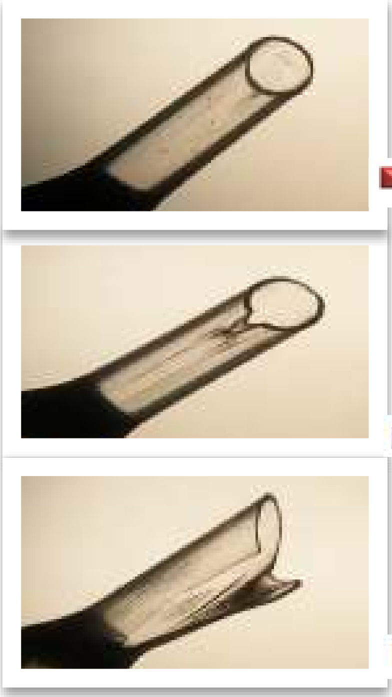
*hydrophobic IOL material

slight scratches

*Data on file: David J. Apple International Laboratory for Ocular Pathology, Dept. of Ophthalmology, University-Eye-Clinic Heidelberg

Zeiss Accuject injector (2.2)*

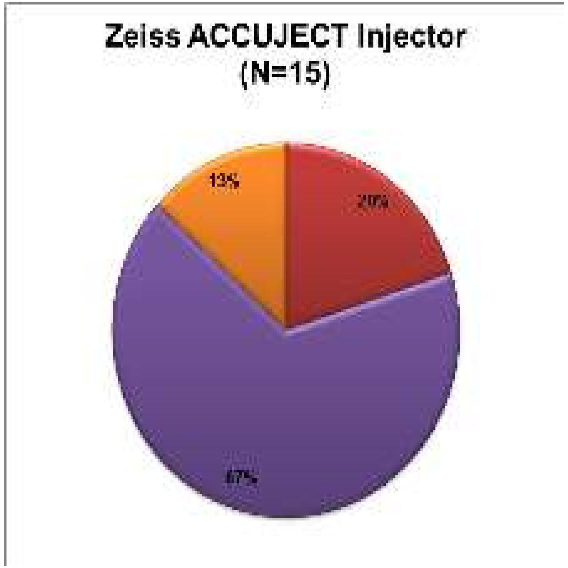
*hydrophilic IOL material



slight scratches

extensions

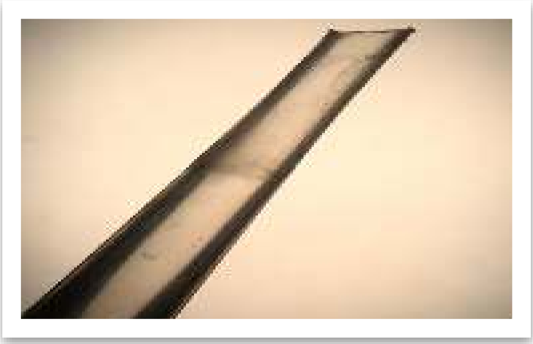
cracks and burst



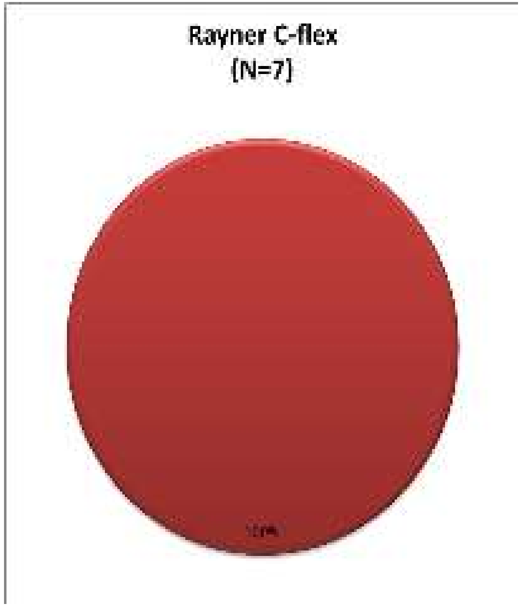
*Data on file: David J. Apple International Laboratory for Ocular Pathology, Dept. of Ophthalmology, University-Eye-Clinic Heidelberg

Rayner RaySert Plus injector system*

*hydrophilic IOL material

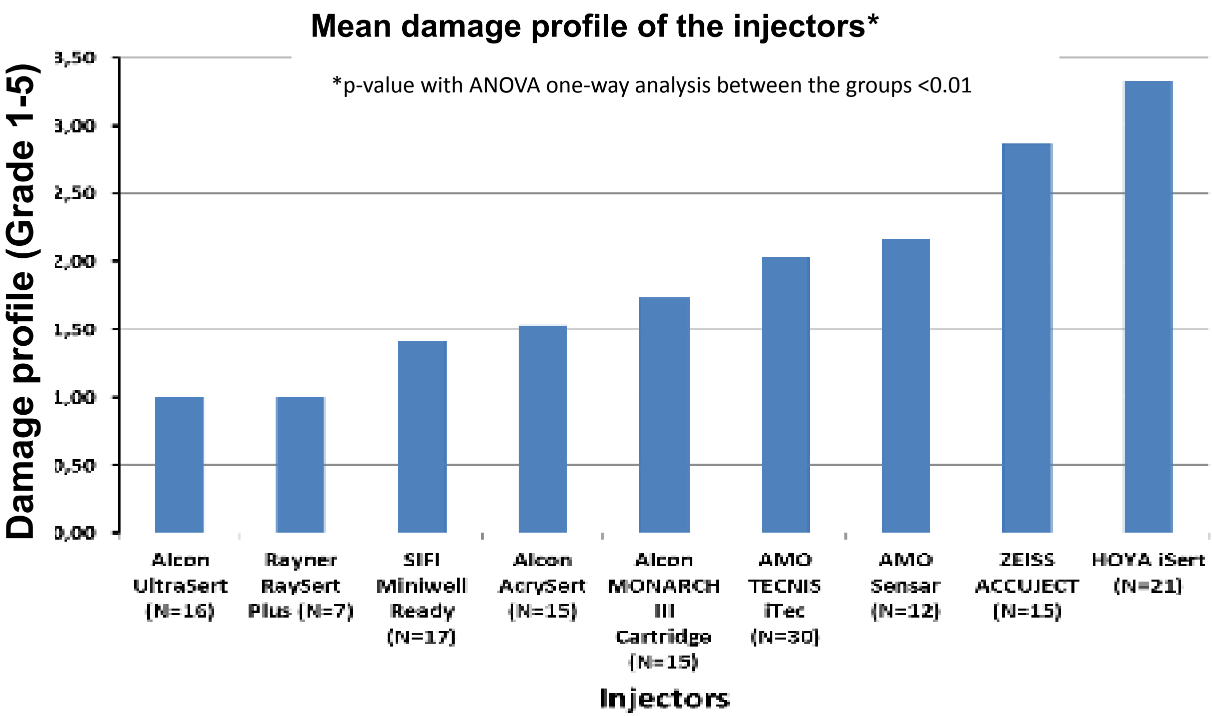


slight scratches



*Data on file: David J. Apple International Laboratory for Ocular Pathology, Dept. of Ophthalmology, University-Eye-Clinic Heidelberg

Mean damage profile of the injector systems

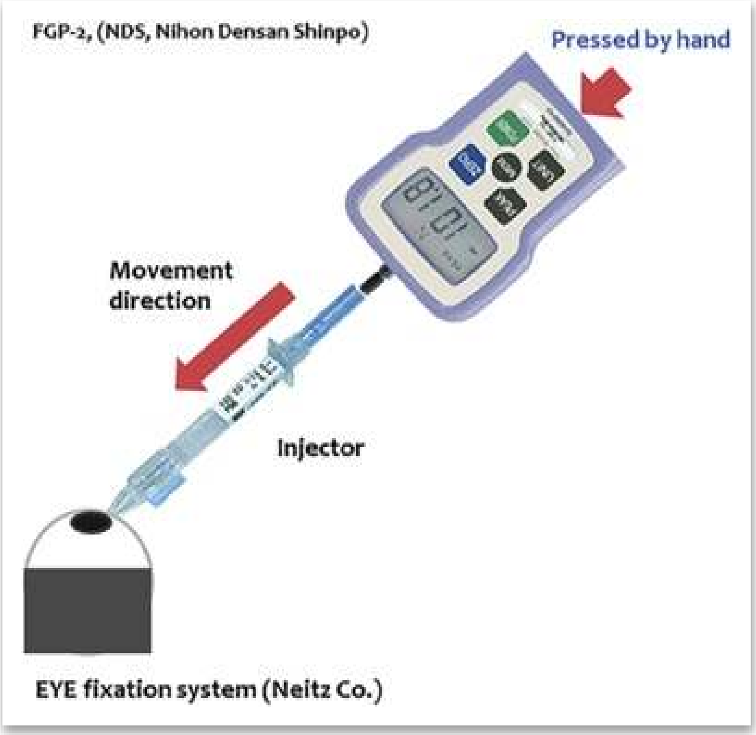


*Data on file: David J. Apple International Laboratory for Ocular Pathology, Dept. of Ophthalmology, University-Eye-Clinic Heidelberg

Ex-vivo autopsy eye studies
Dynamic examination methods

Measurement of the resistance force during implantation with different injector systems

Materials and Methods*



Resistance measurement: FGV-10XY, Shimpo instruments

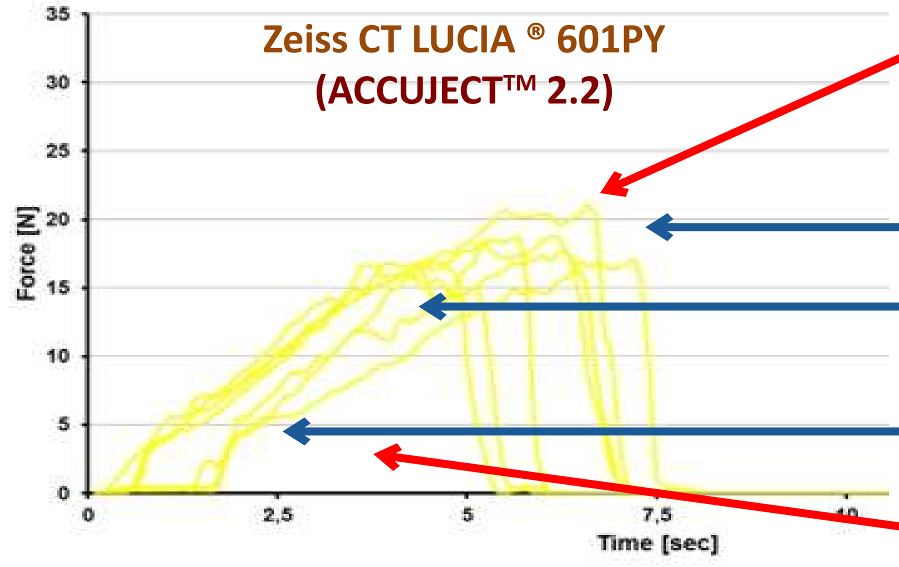
Software: Shimpo Toriemon Force Gauge Software

System Group	Manufacturer	IOL type	Injector model	Incision size(millimetre)	OVD
A	Alcon Laboratories, Inc.	AcrySof® IQ AU00T0	UltraSert™	2.2	Viscoat®
B	Cristalens Industrie	ARTIS® PL E	ACCUJECT™ 1.8	1.8	Pe-Ha-Visco®
C	KOWA Company, Ltd	Avansee™Preset 1P	AvanseePreload	2.4	Pe-Ha-Luron® F
D	NIDEK CO.,LTD	Aktis SP (NS-60YG)	Nex-Load System SP SZ-1	2.2	POLYVISC®
E	Carl Zeiss Meditec AG	CT LUCIA® 601PY	ACCUJECT™ 2.2	2.2	Z-HYALIN®

*Data on file: David J. Apple International Laboratory for Ocular Pathology, Dept. of Ophthalmology, University-Eye-Clinic Heidelberg

Results: Resistance force measurement

Total resistance force measurement during the implantation procedure



analysis:
max. resistance value

implantation procedure:

IOL enters the anterior chamber

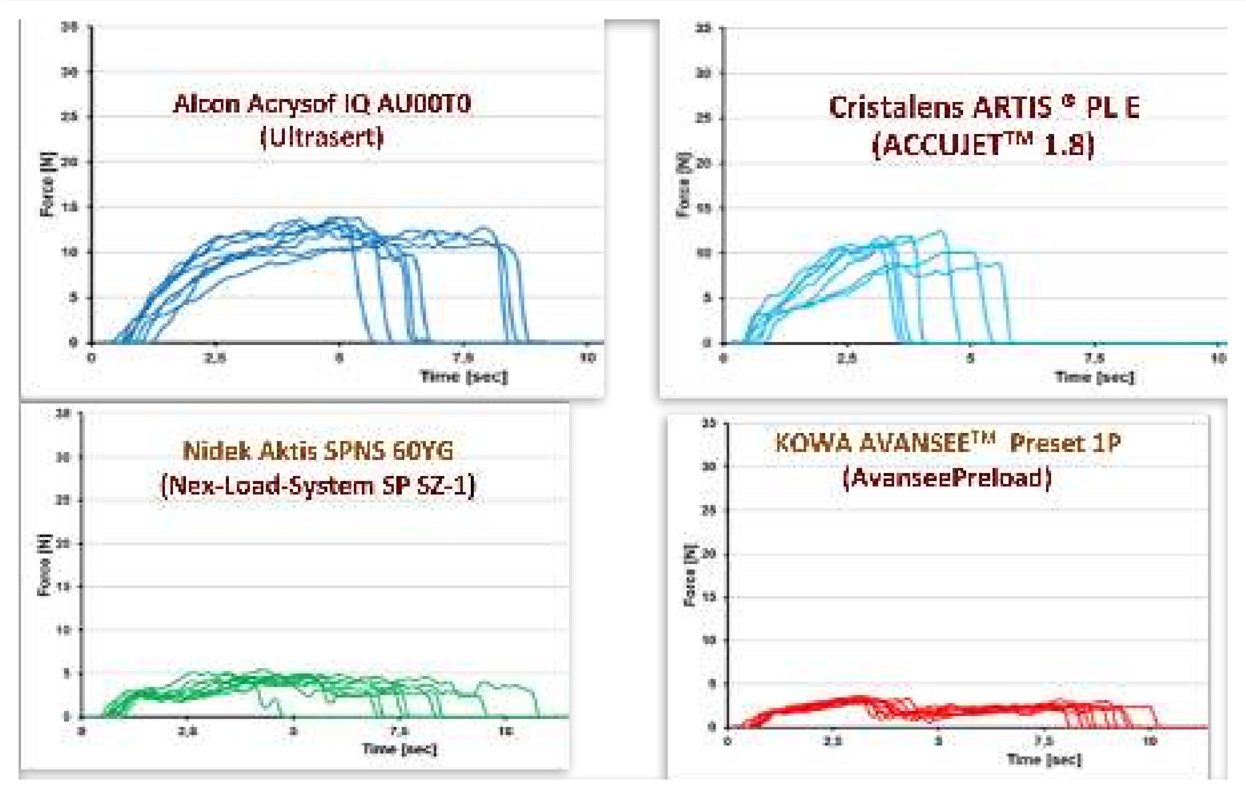
Pushing the IOL through the corneal incision

Pushing the IOL through the injector

analysis:
area under the curve

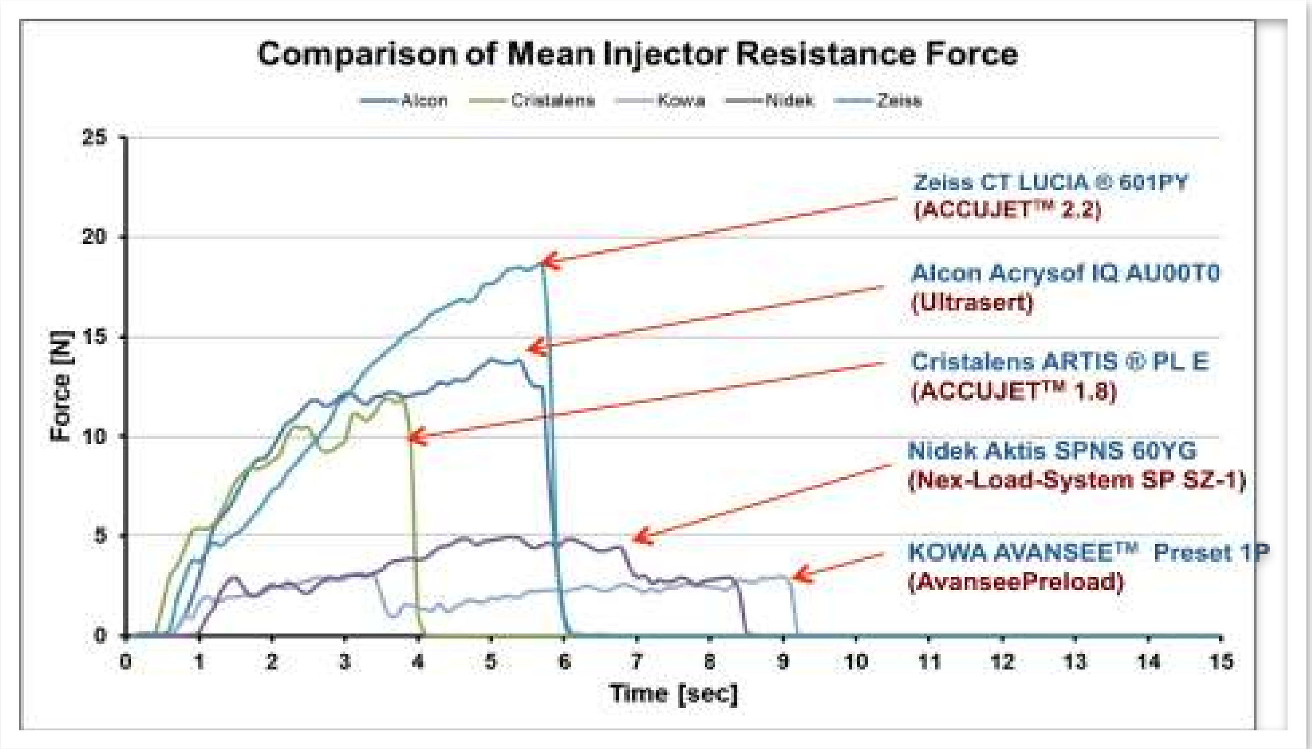
*Data on file: David J. Apple International Laboratory for Ocular Pathology, Dept. of Ophthalmology, University-Eye-Clinic Heidelberg

Results: Resistance force measurement*



*Data on file: David J. Apple International Laboratory for Ocular Pathology, Dept. of Ophthalmology, University-Eye-Clinic Heidelberg

Results: Resistance force measurement*



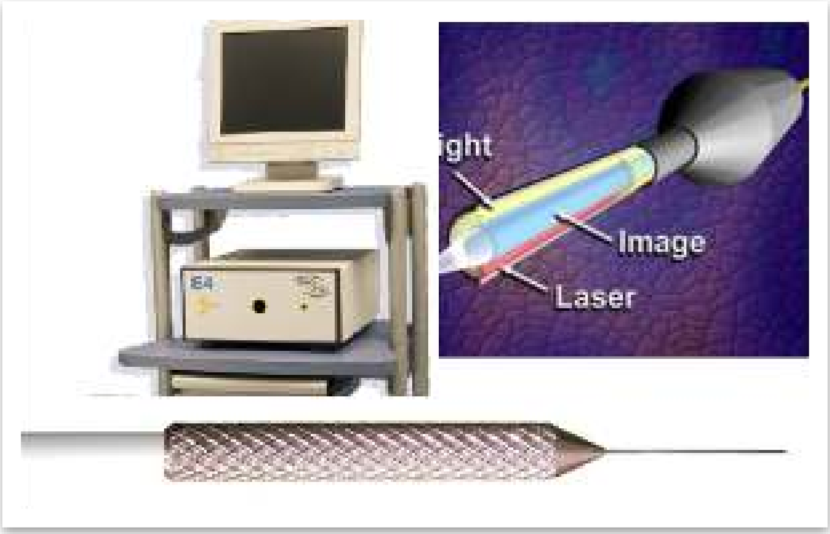
*Data on file: David J. Apple International Laboratory for Ocular Pathology, Dept. of Ophthalmology, University-Eye-Clinic Heidelberg

Ex-vivo autopsy eye studies

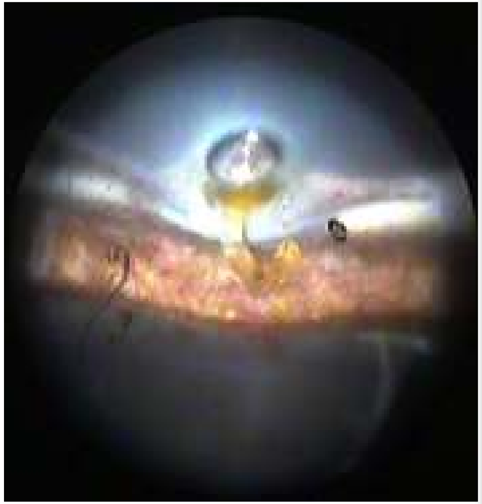
Dynamic examination methods

Implantation procedure

Dynamic analysis methods



Beaver Visitec E4 intraocular endoskope



Endoscopic anterior chamber perspective

Miyake-Apple Posterior View

Example: iSert™ injector: development cycles

HOYA

iSert® 230 IOL

HOYA

iSert® 251

HOYA

iSert® Vivinex

MultiSert™ injector: push- or screw-mode

MultiSert™ implantation: Push-mode with „*insert shield*"*

- One-handed "push implantation"
- Insertion with "Insert shield" through the corneal tunnel

Beaver Visitec E4 intraocular endoscope

*Data on file: The David J. Apple International Laboratory for Ocular Pathology, University Eye Clinic, Heidelberg

Implantation in push-mode with "insert shield"

- One-handed "push implantation"
- Insertion with "Insert shield" through the corneal tunnel

"*

*Data on file: The David J. Apple International Laboratory for Ocular Pathology, University Eye Clinic, Heidelberg

Dynamic analysis „Apple-Choi-Side View“

Effects of injector implantation on the capsular bag and zonules

„Apple-Choi-Side View“*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New Developments in Vision Research

Lenticular Imaging: A New Experimental and Quantitative Analysis of Capsular Dynamics, "Choi-Apple View"

Introduction

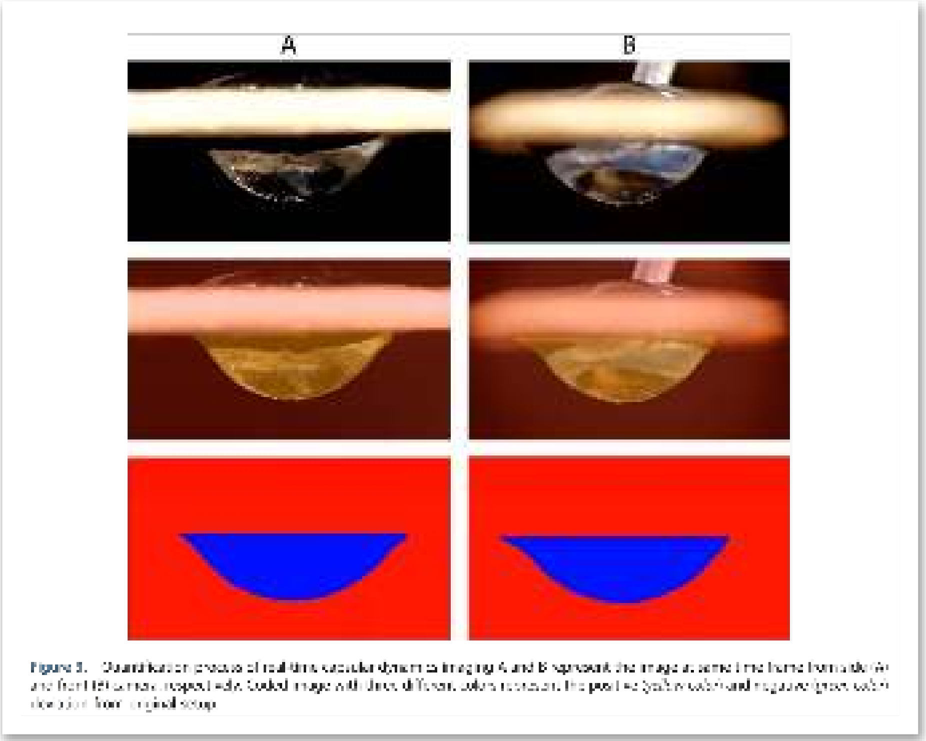
Purpose: To develop a method for quantitative estimation of capsular bag and zonular dynamics using real-time imaging of human autopsy eyes during implantation of different intraocular lens models using different injector systems.

*Son HS, Shin KU, Kim D, Merz P, Tandogan T, Khoramnia R, Auffarth GU, Friedmann E, Chae S, Lee KH, Choi CY. Lenticular imaging: a new experimental and quantitative analysis of capsular dynamics, ‘‘Choi-Apple view’’. Trans Vis Sci Tech. 2019;8(3):22, https://doi.org/ 10.1167/tvst.8.3.22

UK HD

„Apple-Choi-Side View“*

translational vision science & technology



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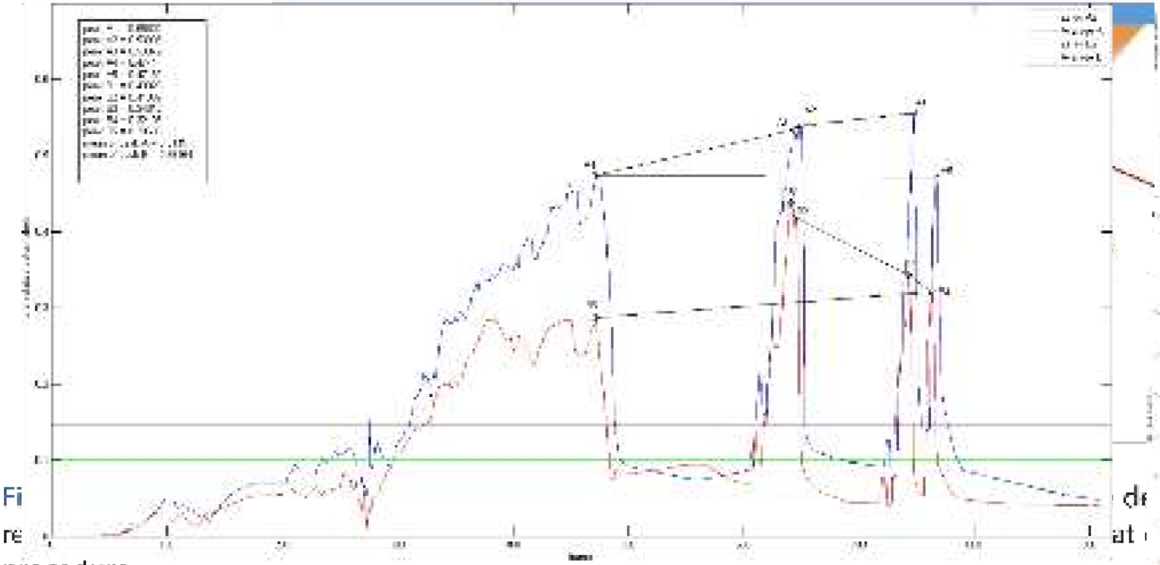
„Apple-Choi-Side View"*



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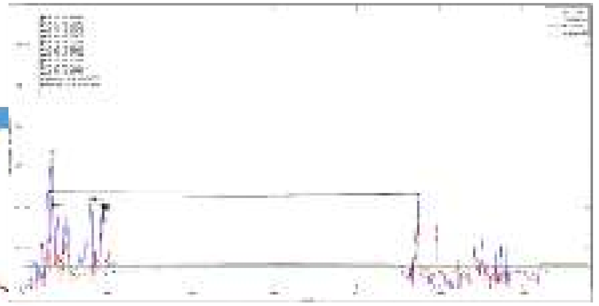
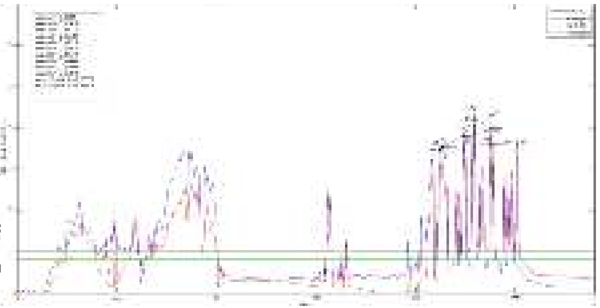
procedure.

Figure 6. Real-time graphs during period of IOL 3 implantation one-piece plate-type IOL (CT Asphina 509MP, Bluemix 180 injector, Zeiss).





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*Son HS, Shin KU, Kim D, Merz P, Tandogan T, Khoramnia R, Auffarth GU, Friedmann E, Chae S, Lee KH, Choi CY. Lenticular imaging: a new experimental and quantitative analysis of capsular dynamics, ''Choi-Apple view''. Trans Vis Sci Tech. 2019;8(3):22, https://doi.org/ 10.1167/tvst.8.3.22

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Apple-Choi-Side View*

translational vision science & technology

Table. Overview of the Measured Peak Movement Values and Their Average Values for Each IOL Type as Measured by Cameras A and B

	One-Piece C-Loop Haptic IOL Peak Values		Three-Piece C-Loop Haptic IOL Peak Values		One-Piece Plate Haptic IOL Peak Values	
	Side (A)	Front (B)	Side (A)	Front (B)	Side (A)	Front (B)
1	34%	22%	43%	42%	59%	44%
2	24%	21%	43%	40%	54%	42%
3	23%	20%	38%	38%	55%	34%
4	22%	20%	36%	36%	47%	32%
5	20%	17%	35%	35%	41%	28%
Mean	25%	20%	39%	38%	51%	36%

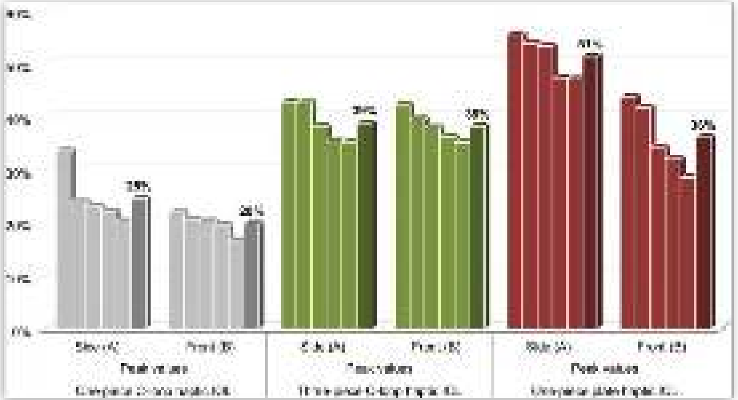

Figure 7. Comparison of the peak movement values and their mean values between three different IOL types.

*Son HS, Shin KU, Kim D, Merz P, Tandogan T, Khoramnia R, Auffarth GU, Friedmann E, Chae S, Lee KH, Choi CY. Lenticular imaging: a new experimental and quantitative analysis of capsular dynamics, ‘‘Choi-Apple view’’. Trans Vis Sci Tech. 2019;8(3):22, https://doi.org/ 10.1167/tvst.8.3.22

Studies in the David J. Apple laboratory in Heidelberg

- Static and dynamic evaluation of injector systems and their implants
- Human autopsy eyes and/or pig eyes as a model
- Classic Miyake-Aple technique
- New techniques e.g. high-speed camera/intraocular endoscope/ Choi-Apple View
- Results show errors/problems with injector systems
- Development studies/comparative studies/measurable data

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UNIVERSITY EYE CLINIC 150 Years

DAVID J APPLE LABORATORY

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EUROPEAN VISION CLINICAL RESEARCH

Steinbeis-Forschungszentrum
The David J Apple Center
for Vision Research

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