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**LASER REFRACTIVE CATARACT SURGERY –  
OVERVIEW OF LASER SYSTEMS**


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Mannheim, Germany


**Charles Kelman, 1967**



An anniversary  
ation  
ration

AMERICAN SOCIETY OF CATARACT & REFRACTIVE SURGERY  
25 Years of  
1974 1999

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## Phaco 1967 - What is next ?

- [Laser Refractive Cataract Surgery](#)  
using a femtosecond laser !
  - 2008: first surgery performed in Budapest by Zoltan Nagy using **Alcon LenSx** laser
  - 2009: **Alcon LenSx** first laser to receive FDA approval for cataract surgery
  - 2010: first surgery in the US performed by Stephen Slade using **Alcon LenSx** laser



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## OVERVIEW OF LASER SYSTEMS



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## Laser Systems

- Alcon LenSx (CA, USA)
- OptiMedica CATALYS (CA, USA)
- LensAR (FL, USA)
- Technolas VICTUS (Munich, GER)
  
- Others



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## Alcon LenSx

- Femtosecond laser
- OCT
  
- 510K approvals
- CE marked
  - Capsulorhexis
  - Liquefaction
  - Corneal incisions (AK !)



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## OptiMedica CATALYS

- Liquid Optics Interface
- OCT
- Femtosecond laser
  
- CE-marked for
  - Capsulorhexis
  - Lens fragmentation



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## LensAR Laser

- Initially designed to soften lens to correct presbyopia
- Picosecond laser
- Scheimpflug camera, not real-time
  
- 510K approval for
  - Capsulotomy
  - Lens fragmentation



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## Technolas VICTUS

- **Femtosecond laser**
- **Only combined platform**
  - Flaps
  - Corneal transplants
  - AK
  - INTRACOR
  - *Capsulorhexis*
  - *Lens fragmentation*



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## Other Systems

- **AMO IntraLase iFS**
  - „Flapmaker“
  - Astigmatic cuts
  - Incisions?
  - (Capsulorhexis?)
  - (Fragmentation?)



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## My Personal Experience

- Alcon LenSx laser
- Surgery performed in Budapest, Hungary
- Alcon LenSx laser in Mannheim since 7-2011



## OR Setup, Mannheim, Germany



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## OR Setup, Mannheim, Germany



## Why Laser Refractive Cataract Surgery ?


- Capsulorhexis
- Lens fragmentation / liquefaction
- Corneal incisions
- Astigmatism correction





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**PEER-REVIEWED LITERATURE**

**First Paper on LRCS !**

**ORIGINAL ARTICLES**

**Initial Clinical Evaluation of an Intraocular  
Femtosecond Laser in Cataract Surgery**

Zoltan Nagy, MD; Agnes Takacs, MD; Tamas Filkorn, MD; Melvin Sarayba, MD

**C**ataract surgery with intracocular lens (IOL) implantation is the most common ophthalmic surgical procedure worldwide. It is also the most common surgery that corrects refractive error, performed over five times more frequently than corneal refractive surgery.<sup>1</sup> Phacoemulsification is the dominant form of cataract surgery in developed countries, accounting for >90% of procedures.<sup>2,3</sup> Although a number of recent developments have occurred in IOL technology, the basic phacoemulsification procedure has remained largely unchanged over the past 20 years, involving a series of individual steps including corneal incision creation, capsulorhexis, and phacofragmentation.

Although highly successful, each of these manual steps presents an opportunity for improvement in both safety and effectiveness. For example, manual capsulorhexis results in capsular tears in approximately 1% of cases and has limited diameter predictability, which can affect IOL centration, postoperative anterior chamber depth, and posterior capsular opacification rates.<sup>4,5</sup> The surgical challenges posed by nuclear chopping techniques have hindered widespread adoption, despite evidence that they reduce ultrasound requirements relative to traditional phacoemulsification.<sup>6,7</sup>

Femtosecond lasers represent an important technological advance in ophthalmic surgery. Combined with computer-controlled optical delivery systems, femtosecond lasers can produce precise surgical incisions without collateral damage to surrounding tissues.<sup>8-11</sup> Since 2001, several femtosecond laser systems have been introduced clinically and more than 2 million ophthalmic procedures have been performed with femtosecond lasers, primarily for creation of a corneal flap in LASIK. The precision of femtosecond lasers exceeds that of

thesis and reduced phacoemulsification power in porcine and human eyes. *J Refract Surg.* 2009;25:1053-1060. doi:10.3929/10815977430091117-04

From the 1st Department of Ophthalmology, Semmelweis University, Budapest, Hungary (Nagy, Takacs, Filkorn), and LenSx Lasers Inc, Allen, Va., Calif (Sarayba).

Dr Nagy is a paid consultant to LenSx Lasers Inc. Dr Sarayba is an employee of LenSx Lasers Inc. Drs Takacs and Filkorn have no financial interest in the materials presented herein.

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## How strong is the Laser CCC ?

- Nagy Z, Takacs A, Filkorn T, Sarayba M  
**Initial Clinical Evaluation of an Intraocular Femtosecond Laser in Cataract Surgery**  
*J Refract Surg 2009; 25:1053-1060*
  - 8 porcine eyes each group, 5-mm CCC using corneal mark
  - CCC stretched with calipers, ratio calculated

### **Laser CCC slightly stronger than manual**

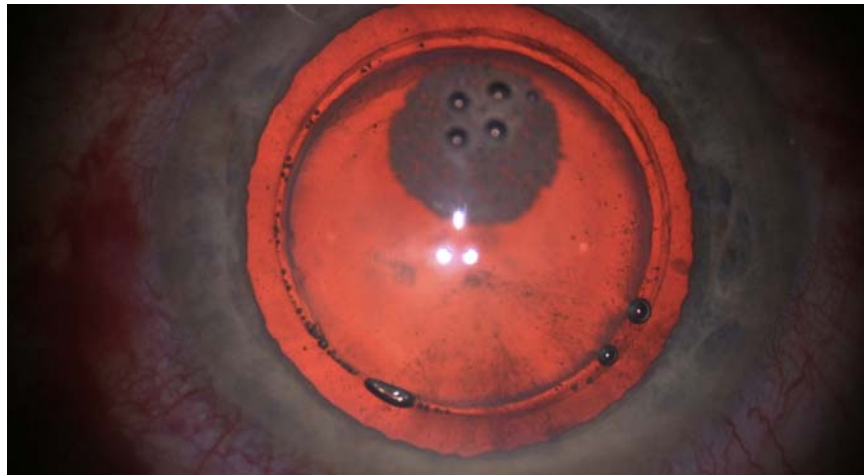
- Laser CCC ratio 2.13 +/-0.03 (range, 2.07 – 2.17)
- Manual CCC ratio 1.98 +/-0.08 (range, 1.84 – 2.09)



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## Laser Capsulorhexis

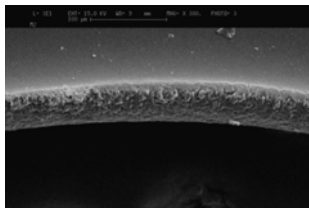
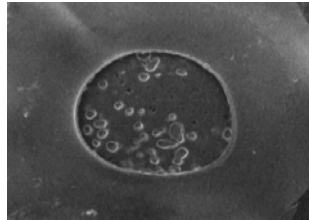


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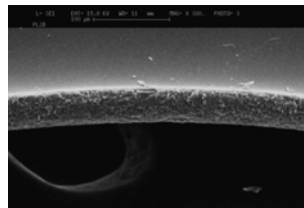
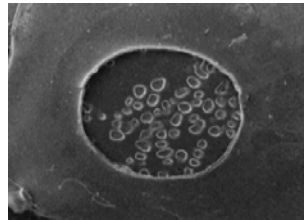


# LenSx Laser Capsulorhexis SEM

Manual Capsulorhexis



LenSx Capsulotomy



Porcine eyes 10x and 300x



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ORIGINAL ARTICLE

## Femtosecond Laser Capsulotomy and Manual Continuous Curvilinear Capsulorhexis Parameters and Their Effects on Intraocular Lens Centration

Kinga Kránitz, MD; Agnes Takacs, MD; Kata Miháztz, MD; Illés Kovács, MD, PhD; Michael C. Knorz, MD; Zoltán Z. Nagy, MD, DSC

**C**reation of a precise anterior capsulorhexis is one of the most important steps of cataract surgery. In recent years, the most commonly used technique during phacemulsification is continuous curvilinear capsulorhexis (CCC). Popularized by Gimbel and Nisham,<sup>1-3</sup> CCC has several surgical and postoperative advantages but its completion takes special attention and surgical expertise. Obtaining a precise capsulorhexis is essential to reach demanding refractive results because a properly sized and well-centered capsulorhexis with a 360° overlapping capsular edge prevents optic decentration, tilt, myopic shift, posterior and anterior capsular opacification due to symmetric contractile forces of the capsular bag, and shrink wrap effect.<sup>4,5</sup> However, an eccentric or irregularly shaped capsulorhexis with a diameter extending beyond the optic edge may lose these advantages.

Until now, capsulorhexis has been a manual procedure. With the advent of femtosecond lasers in ophthalmic surgery, a predictably sized and centered anterior capsulotomy became possible through a laser-tissue interaction known as photodisruption.<sup>6-8</sup> Femtosecond lasers were initially developed for LASIK flap creation during corneal refractive surgery. Recently introduced laser technology enables surgeons to achieve efficient lens fragmentation or liquefaction and precise and reproducible creation of capsulotomies and corneal incisions during refractive cataract surgery.<sup>9-14</sup>

The purpose of this study was to measure and compare sizing and positioning parameters of the femtosecond laser capsulotomy with manual CCC during 1-year follow-up. We also studied the effects of these differences on IOL centration. To our knowledge, no such comparisons have been performed previously.

relation was noted in the femtosecond group ( $P < .05$ ).

**CONCLUSIONS:** More precise capsulotomy sizing and centering can be achieved with femtosecond laser. Properly sized, shaped, and centered femtosecond laser capsulotomies resulted in better overall parameters that help maintain proper positioning of the IOL. *J Refract Surg.* 2011;27(10):558-563.

From Semmelweis University Budapest, Faculty of Medicine, Department of Ophthalmology, Hungary (Kovács, Takacs, Miháztz, Nagy, and Knorz); Faculty Mannheim, University of Heidelberg, Mannheim, Germany (Kranitz).

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# Capsulotomy Shape and Diameter

- Kranitz K, Takacs A, Mihaltz K, Kovacs I, Knorz MC, Nagy Z  
**Femtosecond laser capsulotomy and manual CCC parameters and their effects on IOL centration**  
*J Refract Surg 2011; 27:558-563*
- *Laser CCC 20 eyes, Manual CCC 20 eyes; 1 year data*
- *Vertical and horizontal diameter an capsule overlap measured with Adobe Photoshop*

**Circularity of CCC better after Laser CCC**  
**Greater IOL / capsule overlap after Laser CCC**



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## Comparison of Intraocular Lens Decentration Parameters After Femtosecond and Manual Capsulotomies

Zoltán Zsolt Nagy, MD, DSC; Kinga Krántz, MD; Agnes I. Takacs, MD; Kata Miháltz, MD; Illés Kovács, MD, PhD; Michael C. Knorz, MD

**M**yopia and cataract are common disorders in the human population. Highly myopic eyes are more likely to develop cataract.<sup>1</sup> Cataract surgery has become a common, safe, and effective intervention performed worldwide.<sup>2</sup> However, surgery in eyes with long axial length is associated with increased risk of intra- and postoperative complications.<sup>3</sup>

Posterior capsular opacification is the most common surgically related cause of reduced vision after cataract surgery. Capsulorhexis size, centration, and completely overlapping anterior capsule on the optic edge of the intraocular lens (IOL) affect the severity of this disorder. Although new IOL designs have diminished the incidence of posterior capsular opacification, a precise anterior capsulotomy is a crucial step in preventing the migration of lens epithelial cells.<sup>4,5</sup> Complete overlap helps prevent not only posterior capsular opacification but also results in better IOL centration and less myopic shift by maintaining the IOL in the proper position.<sup>6,7</sup>

In recent years, the most commonly applied technique during phacemulsification is continuous curvilinear capsulorhexis. Popularized by Gimbel and Noubhan,<sup>8,9</sup> it has several surgical and postoperative advantages, but special attention and surgical expertise are needed to complete it successfully. In highly myopic eyes, the larger size of the eye and pupillary diameter and optical distortion by the cornea may oblige surgeons to prepare a larger capsulorhexis than intended.<sup>10-12</sup> This makes IOL malpositioning (eg, decentration, tilt, and luxation due to improper fixation in a larger capsular bag) more likely and may cause myopization and an increase in higher order aberrations.<sup>13,14</sup>

in the FS group (P > .05).  
**CONCLUSIONS:** Femtosecond laser capsulorhexis was more regularly shaped, showed better centration, and showed a better intraocular lens/capsule overlap than manual capsulorhexis. *J Refract Surg.* 2011;27(8):564-569. | doi:10.3928/10815971-201110067-01

From Mannheim University Hospital, Faculty of Medicine, Department of Ophthalmology, Hungary (Nagy, Krántz, Takacs, Miháltz, Kovács) and Medical Faculty Mannheim, University of Heidelberg, Mannheim, Germany (Knorz).  
Dr Nagy and Knorz are consultants to LenSx Lasers Inc. The remaining authors have no proprietary interest in the materials presented herein.  
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# Capsulotomy and IOL Centration

- Nagy Z, Kranitz K, Takacs A, Mihaltz K, Kovacs I, Knorz MC  
**Comparison of IOL decentration parameters after femtosecond and manual capsulotomies**  
*J Refract Surg 2011; 27:564-569*
- *Laser CCC 54 eyes, Manual CCC 57 eyes*
- *Circularity and IOL decentration at 1 week (Adobe Photoshop)*
- *Axial length and ACD with Lenstar LS 900 (Haag-Strait)*

**Circularity of CCC better after Laser CCC**  
**Better IOL centration after Laser CCC**



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ORIGINAL ARTICLES

## Internal Aberrations and Optical Quality After Femtosecond Laser Anterior Capsulotomy in Cataract Surgery

Kata Miháltz, MD; Michael C. Knorz, MD; Jorge L. Alió, MD, PhD; Agnes I. Takács, MD; Kinga Kránitz, MD; Illés Kovács, MD, PhD; Zoltán Z. Nagy, MD, DSc

**P**erforming a precise anterior capsulorhexis is crucial in cataract surgery. A capsulorhexis with a 360° overlapping capsular edge prevents optic dislocation, tilt, myopic shift, posterior and anterior capsular opacification due to symmetric contractile forces of the capsular bag, and shrink wrap effect.<sup>1,2</sup> In earlier reports from our research group, we have demonstrated higher precision capsulorhexis creation and reduced lens decentration with the intracocular femtosecond laser.<sup>3,4</sup> This technology also has the potential to reduce the risk of capsular tear and intraoperative complications during cataract surgery and reduced phacemulsification power.<sup>5</sup>

Optical quality is a subjective entity and can currently only be described indirectly by objective metrics, such as wavefront error measurements, and visual quality metrics or functional data, such as visual acuity and contrast sensitivity.<sup>6,8,10</sup> Wavefront analysis isolates the effect of lower order aberrations (defocus, astigmatism) and higher order aberrations, as well as the contribution of individual aberrations on optical quality. Strehl ratio, point spread function (PSF), and modulation transfer function (MTF) are parameters of the quality of an optical system including a human eye. The PSF of an optical system is the intensity distribution of light from a point source projected onto the retina and indicates the extent of blurring of the retinal image. Modulation transfer function is defined as the amplitude of the image contrast divided by the amplitude of the object contrast and is a function of spatial frequency, which could describe the reduction in contrast of sine wave stimuli by the optical medium. Modulation transfer function can be measured by directly imaging the PSF on

at all measured cycles per degree, compared to the CCC group.

**CONCLUSIONS:** Capsulotomy performed with an intracocular FS laser induced significantly less internal aberrations measured by the MEXX QAO-Scan aberrometer compared to eyes that underwent CCC, which may result in better optical quality after the procedure. (*J Refract Surg*. 2011;27(10):711-716.) doi:10.3929/10815976-20110915-01

From Szeged University Backpact, Faculty of Medicine, Department of Ophthalmology, Budapest, Hungary (Miháltz, Takács, Kovács, Nagy); FreeViz LASER Center, Medical Faculty Mannheim, University of Heidelberg, Mannheim, Germany (Knorz); and the Division of Ophthalmology, Instituto Oculológico de Alicante, Vision Cooperation, Universidad Miguel Hernández, Alicante, Spain (Alió).

Dr Knorz, Alió, and Nagy are consultants for Alcon LenSx Inc. The remaining authors have no financial interest in the materials presented herein.

Correspondence: Kata Miháltz, MD, 10012 Backpact, Mainz a. M., Hungary. Tel: +36 30 449 6290; Fax: +36 1 17 9691; Email: mihaltz@uwm.com

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## Higher-order Aberrations

- Mihaltz K, Knorz MC, Alio JL, Takacs A, Kranitz K, Kovacs I, Nagy ZZ  
**Internal aberrations and optical quality after femtosecond laser anterior capsulotomy in cataract surgery**  
*J Refract Surg 2011; 27:711-716*
- *48 eyes Laser CCC, 51 eyes Manual CCC;*
- *OPD-Scan (Nidek) performed at 6 months*

***Significantly lower tilt and coma after Laser CCC***  
***Significantly higher MTF and Strehl ratio after Laser CCC***



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## MARKET POTENTIAL



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## Issues to Consider

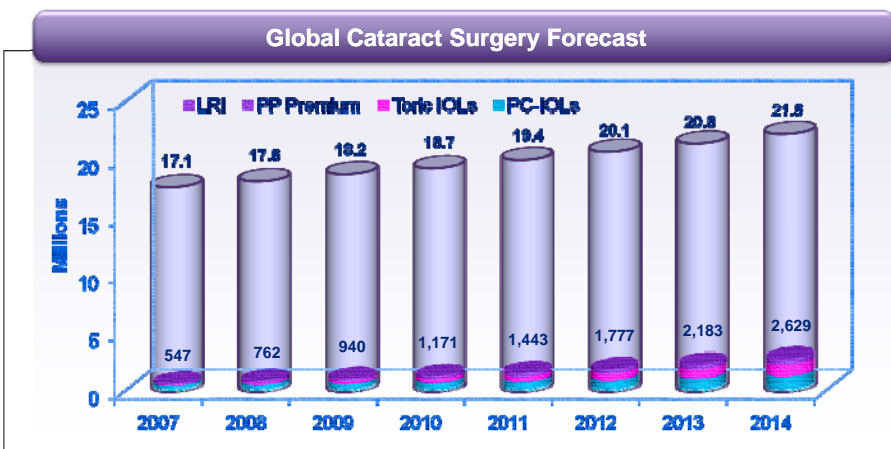
- Can the market support another premium technology ?
- Do we need a laser to improve our clinical performance ?
- Will our patients understand and embrace the technology ?



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## Global Cataract Market



Data: Market Scope 2009 Report



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**Welcome to the Future !**

***Laser Refractive Cataract Surgery***

**A combination of premium technologies  
A premium opportunity for surgeons and patients**



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**THANK YOU !**