Update on Adjustable Intraocular Lens Power Technologies

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Adjustable IOLs

Despite advances in cataract surgery, incorrect intraocular lens (IOL) power remains one of the most frequent causes of IOL exchange.

- 17th annual survey of ASCRS/ESCRS members
- Foldable IOL complications/explantations - 2014
  - Dislocation/decentration overall most common reason for IOL explantation
  - Followed by glare/optical aberrations
  - Incorrect lens power

Overview of Adjustable IOLs

Multicomponent lens (Infinite Vision Optics)
Mechanically adjustable lens (Acri.Tec AR-1)
Repeatedly adjustable lens
Magnetically adjustable lens
Liquid crystal lens with wireless control
Application of femtosecond technology
Application of two-photon chemistry
Light Adjustable Lens (Calhoun Vision)

Invasive adjustment
Non-invasive adjustment

Multicomponent Lens

Multicomponent lens remained intact in 8 cat eyes over a six-month period.
Infinite Vision Optics

Front lens has two IOL components held together by hydrostatic forces as a single lens.

Front lens sits in front of anterior capsule.

Infinite Vision IOL data

Two-year follow-up study on 6 adult patients receiving Infinite Vision IOL

No interlenticular opacification, corneal damage, or rotational instability

Uncorrected and corrected decimal visual acuity improved from 0.11 +/- 0.06 to 0.68 +/- 0.11 and from 0.28 +/- 0.13 to 0.83 +/- 0.16, respectively, over two years

Harmoni (ClarVista)

- Multicomponent modular PC IOL
- Hydrophobic acrylic material
- Small incision surgery
- Possible monofocal, multifocal, or toric correction
Mechanically Adjustable Lens (Acri.Tec)

Adjustment made by moving the cylinder and piston relative to each other.
Adjustment range of 2.0 to 2.5 D (1.5 D/mm)

Animal Studies: 6 rabbit eyes + 14 rabbit eyes

- Rotational stability
- Easy removability
- Mechanical stability during adjustment
- No evidence of intraocular damage on histopathology

Human studies: (35 eyes)

- No difference in VA, inflammation, and IOP up to 15 months
- Myopic refraction improved from +1.0 to -1.75D to 0 to -2.50D
- Increased incidence of PCO (18/35 eyes)
Repeatedly Adjustable IOL

Initial proof-of-concept study: Rotational force required for power adjustment are well below a target max of 1.5 ounce inches. Matthews et al. JCRS 2003

Magnetically adjustable lens = Repeatedly adjustable lens with magnets

Magnetic spindle consisting of samarium-cobalt (SmCo5); external source consisting of neodymium-iron-boride (Nd2Fe14B)

Proof-of-concept studies:
- Focus to within 0.04 D for a 26 D lens
- to within 0.01 D for a 16 D lens
- No out of control leaching

Femtosecond Laser

- First used in 2001 to create a corneal flap during LASIK
- Has applications to astigmatic limbal relaxing incisions, anterior capsulotomy, and lens fragmentation
- Applications to postoperative IOL adjustments?
RIS uses femtosecond laser energy to selectively change the refractive index of a layer of material approximately 50 microns thick within the IOL.

Phase Wrapping Theory

By dividing the surface of the lens into five concentric diffractive zones, its power can be multiplied by five times, i.e., if a single 50 micron lens layer provides up to 5.0 D of correction, then five layers would provide 20.0 D of correction.

Two-photon chemistry

- ΔRI = 0.03, enabling fine-tuning up to 2.5 D
- Toric corrections possible

Schraub M, Hampp N. Ophthalmic Technologies 2011
In Vivo Adjustable IOLs
Light Adjustable Lens (LAL)

- New IOL design
- Lens power modification following implantation

Adding Power to the LAL

Subtracting Power from the LAL

=> change in radii of curvature => change in power
Conclusions

• Incorrect IOL power is a significant problem that deserves our attention. Adjustable IOLs will provide a useful way to correct this problem

• IOLs that can be adjusted invasively: multicomponent, mechanically-adjustable, and repeatedly adjustable IOLs

• IOLs that can be adjusted non-invasively: magnetically adjustable lens, liquid crystal lens with wireless control, Calhoun LAL, and IOLs that can be adjusted via the femtosecond laser or with two-photon chemistry

• Non-invasive adjustment appears more promising than invasive adjustment

• The Calhoun LAL is in stage III of FDA clinical trials and is the lens closest to commercial availability in the US
Thank You