Surgical Correction of Presbyopia

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Presbyopia definition

- The eye condition in which, while corrected for distance, due to age related factors, the affected person is unable to see clearly at short distances.
- The eye condition of insufficient accommodative amplitude for clear near vision when the eye is corrected for distance.
- Presbyopia, while correctable by spectacles or contact lenses, presents a significant functional disability/handicap to the individual, and like in myopia, hyperopia and astigmatism, surgical correction is reasonable in select individuals.

Incidence and Prevalence

- Universal after age 45
- 40% of US population
- 110-120 million people
- 24% myopic (>-1.00)
- 26% hyperopic (>+1.00)
- 50% emmetropic (+0.875 to -0.875)
- 30% also with astigmatism over 1 diopter

Key Moments in History of Presbyopia

- Aristotle (384 – 322 BC)
  - First to use term "PRESBYTES" as reference to those suffering eye strain
- Sturm (1697)
  - Coins the term "presbyopia"
  - "Presby" = elderly and "opos" = eye
- Young (1801), Helmholtz (1867)
  - Hypothesized that accomodation resulted from a change in crystalline lens shape and proposed the mechanism of accomodation that is most widely accepted
- Donders (1864), Duane (1915)
  - Developed classical curves describing the decrease in monocular accomodative amplitude with age

Important Concepts

- Accomodation –
  - The eyes dynamic ability to focus under CNS control through a range of power as the distance to the object being observed varies
  - Usually measured in diopters or an accomodative amplitude
- Pseudo-accomodation – a non-dynamic increased depth of focus in an eye, not under CNS control, that is generated by an anatomic feature, such as:
  - Small pupil size
  - Ashperic or multifocal optics
  - Astigmatism

    - Higher order aberrations
- Depth of focus – The range in distance (or diopters) over which an eye or optical system can see a specific target (usually 20/40 and J3)
- Depth of focus = pseudo-accomodation and accomodation
    - * also impacted by lighting and target contrast

Optical Principles that can be Utilized to Increase Depth of Focus / Near Acuity on an Individual eye

- Create multifocal optical system
- Increase higher order aberrations (spherical aberration, coma)
- Create a "hyperprolate" optic
- Utilize hyperfocality
- Induce mild astigmatism
- Small diameter aperture optics
- Increase the corneas refractive index
- Neuroadaptation training

Optical Principles that can be utilized to increase depth of focus of the visual system (in order of current preference by contact lens patients)

- Blended vision (less than or equal to 1.50 diopters of anisometropia). Fusion retained.
- Monovision (greater than 1.50 diopters of anisometropia). Fusion usually lost.
- Modified monovision (one eye set for distance, other eye utilizing one of the optical principles for increasing Depth of Focus)

Neuro-adaptation – all approaches require some neuro-adaptation

- neuroadaptation phases
    - Early phase
    - Late phase
- Additional important phenomena
    - Binocular rivalry
    - Suppression
    - Binocular summation

Monovision Blended Vision

- Most popular approach to presbyopia worldwide
- Gives highest quality of vision
- Aspheric IOL or Custom Ablation
- Visual target
    - Distance eye : plano to -0.50
    - Near eye : -1.25 to -1.75
- Contact lens trial is not predictive of success (dislike of CL experiences)
- Issues
    - Reduced binocular summation
    - Reduced stereopsis
    - Anisekonia (4-6%)

- 5-10 % do not neuroadapt

Multifocal Optics

- Second most popular approach to presbyopia surgery worldwide
- Multifocal optics
  - Refractive
  - Diffractive
  - Hybrid
- Multifocal optics
  - Distance dominant
  - Near dominant
  - Symmetrical

Multifocal optics are often PUPIL DEPENDENT in their performance

Issues with multifocal optics

- Reduced contrast sensitivity (25%)
- Night vision symptoms – glare and halo
- Color distortion
- Pupil dependence
- Reduced "quality of vision"
- Concerns with ocular co-morbidities
  - Age-related macular degeneration
  - Glaucoma
  - Corneal dystrophy (Fuchs)
  - Ocular Surface Disease

Reduced quality of vision issues are additive

Multifocal LASIK

3 general methods for Presbyopic Multifocal LASIK (none are FDA approved in USA)

- Central Add – increases central near add
- Peripheral Add – increases the peripheral add for near
- Translational – creates an aspheric surface to increase depth of focus

INTRACOR – Technolas Femtec femtosecond laser

- Creates 5 concentric cylinder shaped intrastromal femtosecond ablations which steepen the central cornea
- Mild hyperopes

Flexivue Microlens

- Disc shaped bifocal refractive power
- Lens implanted into stroma of cornea of non-dominant eye, inside a corneal pocket using a femtosecond laser

Raindrop by Revision Optics

- 1.5 – 2 mm diameter
- Microporous hydrogel
- Biocompatible and stable
- Easily implanted under LASIK flap
- Center near – changed anterior corneal shape

- Exchangeable, removable

Acufocus Corneal Inlay

- 3.8 mm diameter with 1.6 mm aperature
- 5 u thick
- microperforations for nutrient transit
- treats broad spectrum of patients – emmetropes, ametropes, post-LASIK, monofocal pseudophakes

Accomodation IOLs

- 3rd most common approach to lenticular refractive surgery
- mechanism of action is multifactorial – includes increased depth of focus benefits of pseudo-accomodation and accommodation
- quality of vision issues are significantly less than in a Multifocal IOL, but more than with an aspheric monofocal IOL

Issues

- Near vision outcomes are variable
- Surgical technique and post-operative management requires some learning
- Capsular Fibrosis performance in bag – elasticity dependent

Summary

- Monovision / blended vision will remain an attractive option
- Multifocal Optic technology is maturing
- Accomodative IOL development is less mature than multifocal, but is advancing