

# LASIK for presbyopia: monovision, multifocality or both?

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## Introduction on presbyopia approaches

- Dynamic approaches...  
(generating or maintaining or restoring dynamic accommodation capabilities)  
... such as e.g. accommodative IOLs
- Static approaches (pseudo accommodation):
  - Spectacles, contact lenses
  - Refractive lens exchange with bi-/multifocal or progressive IOLs
  - Phakic IOL
  - Corneal inlays
  - Conductive / Laser thermal keratoplasty (CK / LTK)
  - Corneal cuts (intraCOR)
  - ...and **laser refractive surgery.**

## Refractive Laser surgery

- Less invasive and maybe with fewer potential complications than IOL implants.
- The use of **LASIK**, is more adequate for presbyopia:
  - more controllable technique for corneal multifocality, avoiding the plastic compensatory effect of the growing epithelium at surface ablation profiles.
- Very few papers in the literature are found nowadays using surface ablation techniques for presbyopia correction.

## Refractive Laser surgery

Potential refractive laser vision correction approaches for near vision enhancements

- Monovision
- Multifocal ablation
- Increase in depth of focus
- Combined approach



## Monovision

- Binocular approach
- Typically considers eye dominance
- Correction: dominant eye emmetropic (for far) and the fellow eye slightly myopic (for near)
- Initially used with contact lenses
- Should consider patients needs and expectations (occupation, lifestyle, etc)

## Monovision

- Relies on the neuronal adaptation of the overall sighting process within the brain – interocular blur suppression
- **Tolerance** to monovision is limited
  - 59-67% success rate with CL (Evans BJ et al. Monovision: a Review. *Ophthalmic Physiol.Opt.* 2007)
  - 72-97% success rate with LVC – but with **pre-testing** (Reilly CD et al. Surgical monovision and monovision reversal in LASIK. *Cornea* 2006)
  - Best accepted anisometropia in the range from 1.00 to 1.50 dpt (Braun EH et al. Monovision in LASIK. *Ophthalmology*,2008)
- **Tolerance** should be tested in advance

## Monovision

### Advantages:

- Simple
- Preop monovision trial possible
- No compromise in monocular image quality
- Attempted correction is precisely adjustable to patients needs and tolerance

## Monovision

### Disadvantages:

- Not easily reversible compared to CL
- Not always accepted
- Patient motivation and cooperation necessary
- Potential compromises in:
  - Night vision
  - Stereopsis
  - Contrast sensitivity

## Multifocal ablations

Upper distant with lower near (Transitional multifocality):



Anschuetz, Dausch, Klein, Joly (1991)

A profile with significant levels of vertical coma

## Multifocal ablations

Central distant with peripheral near:



- Avalos, Rosakis, Agarval (PARM-technique, 1998), G. Tamayo, 2000, Telandro 2004,

- Pinelli (2008) Presbyopia in Hyperopes.

Efficacy index : UCDVA :1.03, UCNVA: 0.56

Safety index : BCDVA: 1.08, BCNVA: 1.02

- Danasoury (2009) Presbyopia in Hyperopes and Myopes

Satisfaction (spectacle independence):

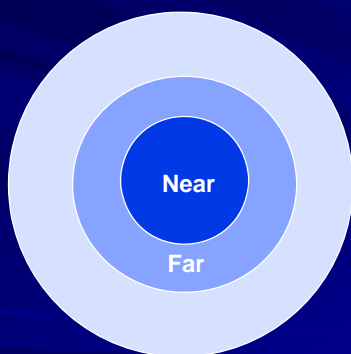
54% in Hyperopes **48% in Myopes**

Efficacy index: UCDVA :0.90/**0.80**, UCNVA: 0.80/1.0

Safety index : BCDVA: 1.11/**0.90**, BCNVA: 1.0/1.0

## Multifocal ablations

Central near with peripheral distant:



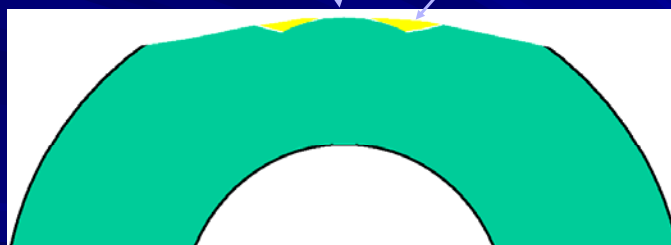
- Luis A Ruiz W Bruce Jackson, VISX (Presbyopic LASIK, 2001)
- Franco Bartoli (Wavefront guided PRK, 2000)
- Seok Won Jung (Multifocal corneal ablation for hyperopic presbyopes 2008)

Efficacy index UCDVA :0.92, UCNVA: 0.53

Safety index BCDVA: 0.94, BCNVA: 0.94

## Multifocal ablations

- Combination of a standard ablation profile (myopic in this example)
- with a small diameter "hyperopic like" profile added in the center



## Multifocal ablations

### Advantages for center near :

- Myosis:
  - pupil contraction during accommodation to near distance supports pseudoaccommodation
- Prolate corneal shape:
  - more refractive power in the pupil center
- Spherical aberration which occurs during accommodation:
  - typical trend for spherical aberration to be shifted toward negative values for near vision
- Less tissue ablation in depth and volume than other multifocal approaches

## Multifocal ablations

### Disadvantages

- Amount of correction is limited
- May need nomogram adjustment
- No preop trial for tolerance possible
- Not easily reversible (customized treatment)
- Induced aberrations cause decreased image quality at every distance
- Effect is reduced over time, with a gradual decline in near vision outcomes

## Depth of focus increase

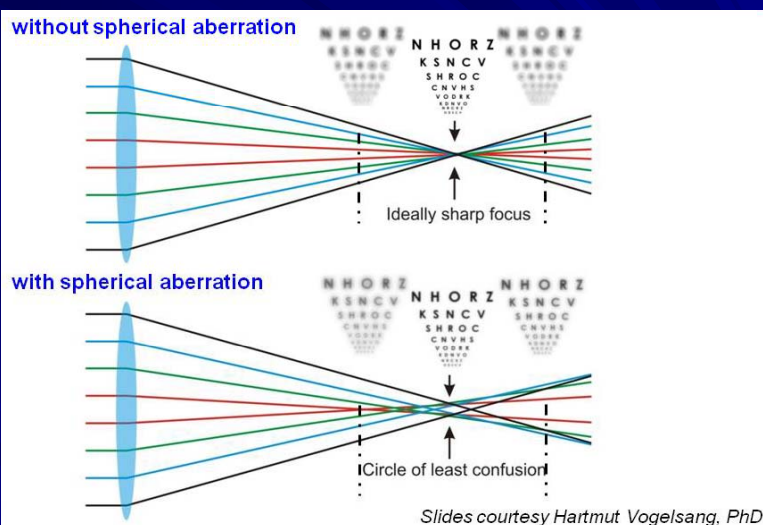
Bartoli 2004

- Superposition of a standard correction profile (in this example myopic) with a spherical aberration profile,  $Z(4,0)$
- This increases the depth of field (DOF) and allows for an acceptably sharp image in a slightly defocused eye



Spherical aberration is related with corneal shape (Q-value) !!!

## Depth of focus increase





## Depth of focus increase

	0.00 D	-0.50 D	-1.00 D	-1.50 D	-2.00 D
<i>without</i> spherical aberration @ 7 mm	N H O R Z K S N C V S H R O C C N V H S V O D R K E D N V O N A C K Z M A G E Y	N H O R Z K S N C V S H R O C C N V H S V O D R K E D N V O N A C K Z M A G E Y	N H O R Z K S N C V S H R O C C N V H S V O D R K E D N V O N A C K Z M A G E Y	N H O R Z K S N C V S H R O C C N V H S V O D R K E D N V O N A C K Z M A G E Y	N H O R Z K S N C V S H R O C C N V H S V O D R K E D N V O N A C K Z M A G E Y
<i>with</i> spherical aberration @ 7 mm	N H O R Z K S N C V S H R O C C N V H S V O D R K E D N V O N A C K Z M A G E Y	N H O R Z K S N C V S H R O C C N V H S V O D R K E D N V O N A C K Z M A G E Y	N H O R Z K S N C V S H R O C C N V H S V O D R K E D N V O N A C K Z M A G E Y	N H O R Z K S N C V S H R O C C N V H S V O D R K E D N V O N A C K Z M A G E Y	N H O R Z K S N C V S H R O C C N V H S V O D R K E D N V O N A C K Z M A G E Y

## Depth of focus increase

- For DOF control the Spherical Aberration (SA) of the entire eye is important !
- Pre-op corneal asphericity is not necessarily related to the spherical aberration of the entire eye due to internal aberrations (→ aging).
- When setting Q-values without having information on the pre-op ocular SA of the eye, which corneal Q-value to aim at in order to optimize SA for DOF control?
- Increasing the prolate shape of the cornea is not a benefit for itself:
  - - It can lead to central island-like post-op condition
  - - It always increases ablation depth

## Depth of focus increase

### Advantages

- Profile is of progressive nature ("continuous multifocal")
- Contour changes are spread out over the complete optical zone
- The spherical aberration (SA) shift does increase the **depth of field**
- Power shift through myosis supports pseudo accommodation

## Depth of focus increase

### Disadvantages

- Amount of excess SA is limited
- Too small effect for daily life (max. approx. 1D)
- Decreased image quality at every distance
- Effect is reduced over time

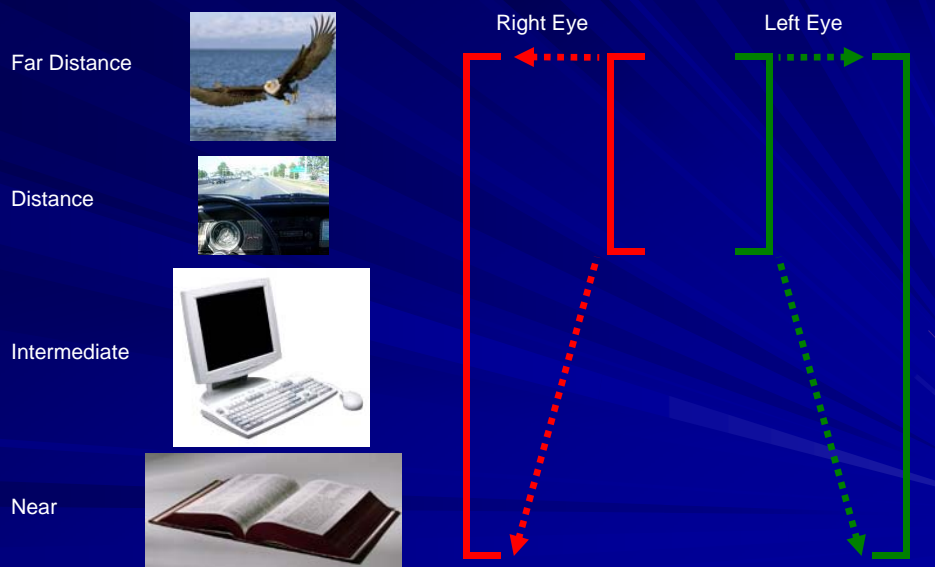
## Combined methods

### Laser Blended Vision/Micro-monovision

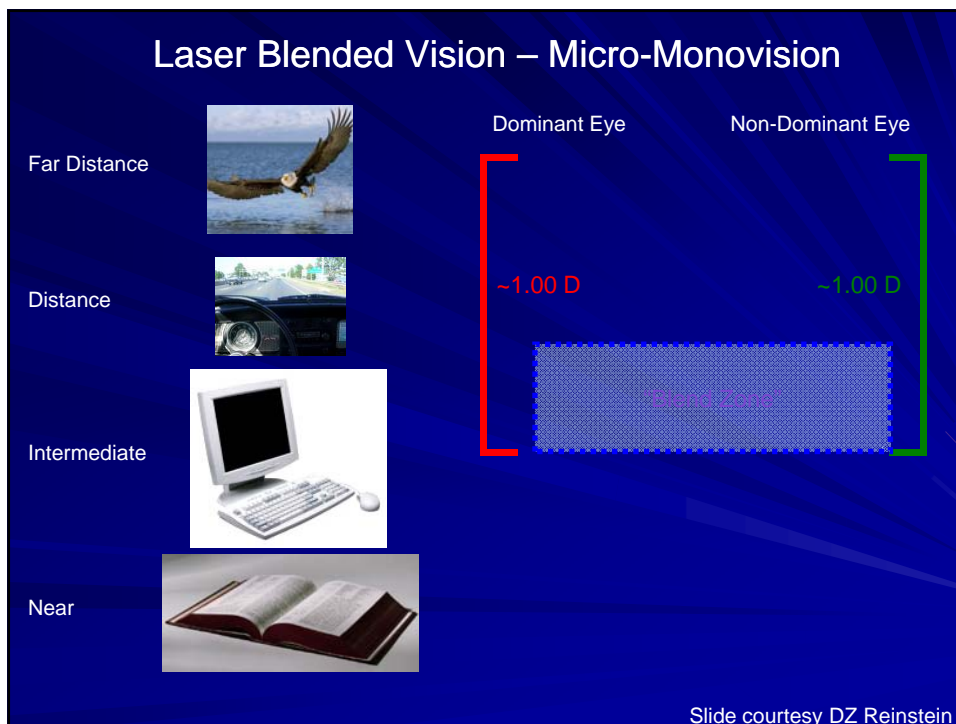
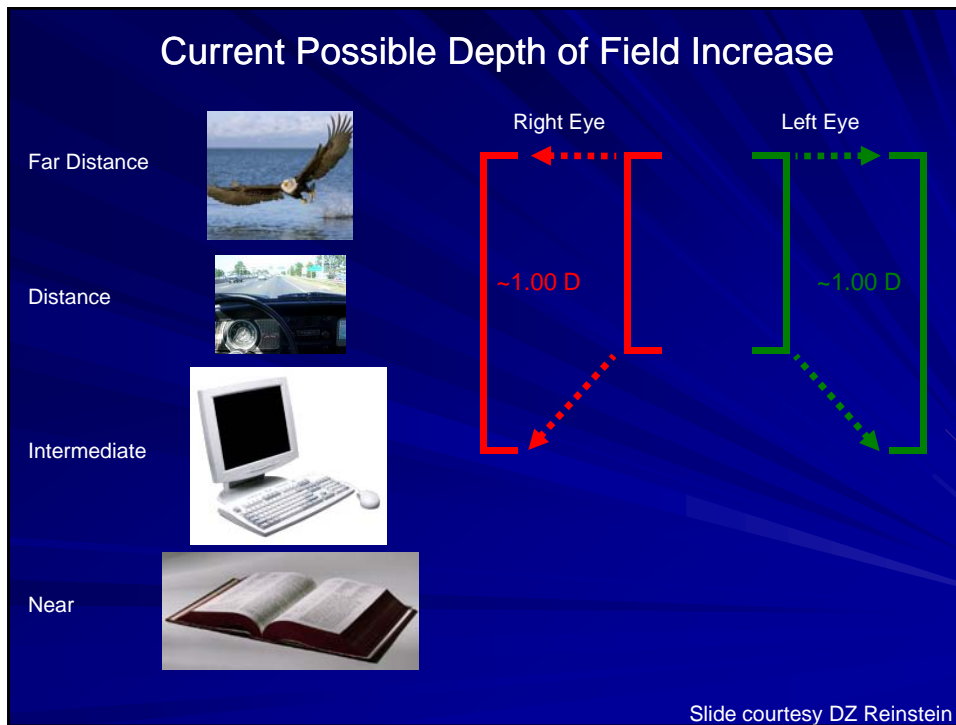
Combining increased depth of field with micro-monovision.

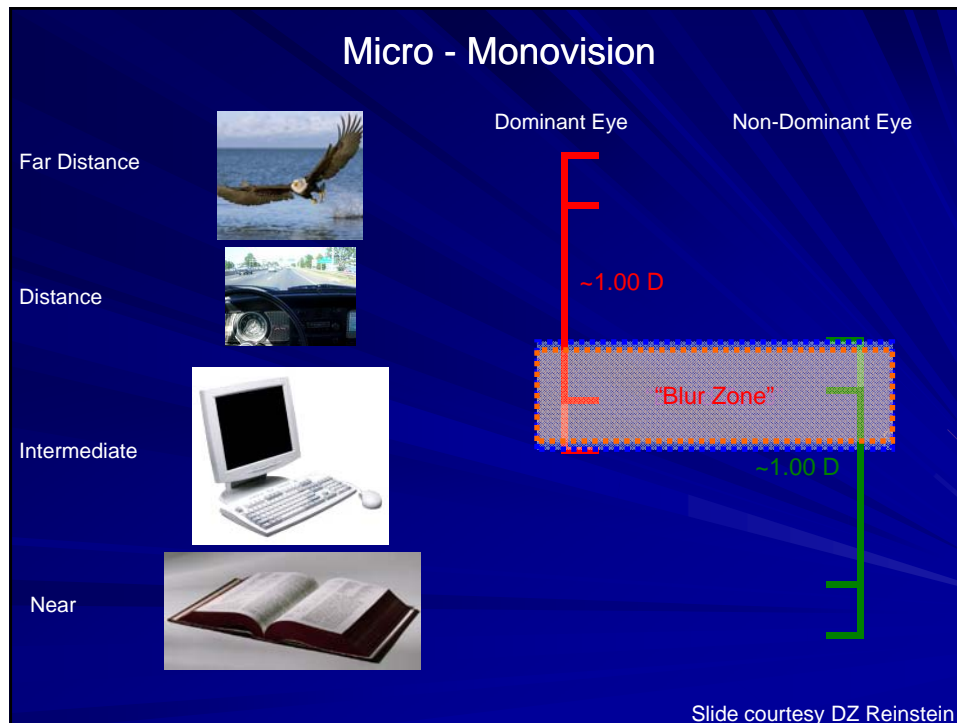
Reinstein DZ et al. LASIK for hyperopic astigmatism and presbyopia using micro-monovision with the Carl Zeiss Meditec MEL80. (2009)

## Presbyopia: Ideal Solution



Slide courtesy DZ Reinstein





## Combined methods

### Advantages:

- Better acceptance than conventional monovision (97% tolerance)
- Although depth of field effect may decrease over time, the monovision remains intact

### Disadvantages:

- Both eyes need to be treated
- Decreased image quality

## Conclusion

Lasik for presbyopia correction can provide high patient satisfaction when the following topics are fulfilled:

- Considering patient's needs and expectations
- Preop tolerance test
- Considering preoperative refractive status
- Reliable laser algorithms
- Analyzing near vision parameters such as
  - Reading speed
  - Light conditions and
  - Print size

## Conclusion

The main limitations of presbyLasik today:

- Few scientific evidence through published data, although it is widely used.
- The dispersion of the techniques.
- The lack of uniformity of the ablation profiles offered by different excimer laser technologies.
- The difficulty in reversing the result especially for multifocal approaches (customization needed).

## Conclusion

- Most probably, presbyLasik will offer a valid alternative for the correction of presbyopia, but scientific evidence is still weak to support its general use today.
- Further studies are necessary to implement the scientific evidence of these techniques. When available, such evidence could generalize this refractive surgery technique, which may offer a huge potential of application, useful for phakic presbyopes and pseudophakic patients.

*Thank you for your kind  
attention*