Laser Treatment in Presbyopia

Krishna Prasad Kudlu, MS
Director, Prasad Netralaya, Udupi, Karnataka

PRESBYOPIA :

Presbyopia is the physiological, progressive age-related loss of accommodation, mostly affecting individuals in their middle age, regardless of any underlying refractive error, causing difficulty in sharply focusing for near vision.[1–3]

Its correction has always been challenging for the refractive surgeon. The static methods for its correction seek to increase the depth of focus, which include: monovision, corneal inlays, presbyLASIK, corneal shrinking techniques (conductive keratoplasty, laser thermal keratoplasty and intrastromal femtosecond laser-based procedures), multifocal IOLs [4]. The dynamic methods such as scleral implants and accommodative IOLs attempt to restore accommodation [4]. A corneal approach seems the safest, since it is the less invasive procedure.

TREATMENT OPTIONS :

• MEDICAL

SPECTACLES: Bifocals/ Progressive/monovision Contact Lens

• SURGICAL

Lens procedures-	Multifocal IOL	Trifocal IOL	Accommodating IOLs	Extended range of vision IOL
Corneal procedures -	LASIK(Presbylasik/Presbyond/Monovision) Inlays			
Supracor/Intracor -	Sclerociliary complex modification - Scleral spacing devices/ LASER ACE procedure			

LASER OPTIONS IN PRESBYOPIA

PRESBYLASIK

The term PresbyLASIK was introduced by Ruiz in 1996 [5]; it is a surgical technique based on the principles of LASIK to create a multifocal corneal surface.It induces spherical aberrations to improve depth of field. It provides good near intermediate vision and reasonable distance vision.

There are 3 main types of multifocal corneal excimer laser profiles: 1) Multifocal transition profile, 2) Central PresbyLASIK, 3) Peripheral PresbyLASIK.

Approaches

Multifocal transition profile

It creates a transitional vertical multifocal ablation based on the creation of an intentional decentration of a hyperopic ablation profile. There are very few reports on this technique and it was not well accepted by surgeons because it induced significant levels of vertical coma [6].

Central PresbyLASIK

It creates a hyperpositive area for the near vision at the center and the periphery is left for far vision. It is pupil dependent and an advantage is that it can be performed at the center of the cornea in myopic and hyperopic profiles,and in emmetropes with minimal corneal excision. Its main limitation is the lack of adequate alignment among the line of sight, the central pupil and the corneal vertex, inducing coma aberrations.e, the central model is more advisable to achieve multifocality due to the physiologic pupil miosis during accommodation [7].

Peripheral PresbyLASIK

In this technique, the center of the cornea is left for distance and the periphery is ablated in a way that a negative peripheral asphericity is created to increase the depth of the field. One of its disadvantages is that when it is used in association with myopic correction, it is necessary to remove a significant amount of corneal tissue and therefore is mainly performed in hyperopes[6].

PROBLEMS IN PRESBYLASIK

- Initial compromise on distance vision (Blurred distance vision till 3 months)
- Adaptation problems to multifocality
- Night vision problems in initial period/contrast changes
- Pupil size dependent procedure

SUPRACOR

Is a pupil dependent, LASIK based procedure which is performed on the TECHNOLAS 217P Excimer laser system[8]. Unlike monovision where one eye is treated for distance and the other is treated for near, this procedure treats both eyes so that both are able to focus on distance and near vision equally.A 3mm central hyperprolate area is created which gives an add of approximately 2 dioptres[8]. It makes use of the central-near,

peripheral-distance concept wherein during natural accommodation when the eye focuses on near objects, the pupil constricts and the eye looks through the near-add elevation. When the eye is looking at a distance, the pupil dilates and allows the peripheral rays to pass through the aspheric optimized periphery to improve distance vision.

PROBLEMS IN SUPRACOR

- It is predominantly a hyperopic treatment, one tends to get a myopic outcome. Leads to an unsatisfactory uncorrected distance vision in considerable amount of patients.
- With the refractive target of –0.50 D spherical equivalent, this adds to the 2.0 D near add, thereby increasing the total add power of 2.5 D So , this procedure will be more suitable for age group from : LATE 40'S
- Patients are found to have large higher order aberrations like vertical coma &quadrafoil, causing considerable visual disturbances post operatively

Supracor can be used in one eye or in both eyes depending on each patient's needs and expectations. The asymmetrical technique is performed in patients that demand both near and distance vision, the symmetrical technique is for patients that demand good near vision

In symmetrical correction:

Targets -0.5 D of myopia in both eyes[9]

Helpful in patents who demand a very good near vision.

In asymmetrical correction:

Dominant eye is done plano, & non dominant eye is done myopic by -0.5D[5]

It gives good near and distance vision

PresbyMAX

PresbyMAX (SCHWIND eye-tech-solutions GmbH, Kleinostheim, Germany) is based on the creation of a biaspheric multifocal corneal surface with a central hyper positive area to achieve +0.75 to +2.50 D of near vision correction, surrounded by an area in which the ablation is calculated to correct the distance refractive error [10, 11□.PresbyMAX allows the safe and efficient treatment of emmetropic, myopic and hyperopic patients as well as patients with astigmatism whose accommodative response is restricted.

With the PresbyMAX module, it is now possible to choose between three different treatment types.

PresbyMAX Symmetric

Treats the dominant and non-dominant eye equally regarding depth of focus and the refractive target, thus ensuring optimal near vision.

PresbyMAX µ-Monovision

This creates the same depth of focus in both eyes. However, the dominant eye focuses slightly more towards near vision. The result: A faster visual recovery and better intermediate and far vision quality.

PresbyMAX ® Hybrid

This is the latest generation and is also based on different target values. But in contrast to µ-Monovision, a different depth of focus is generated in the dominant and non-dominant eye. This ensures an extremely fast visual recovery and an especially high quality of distance vision.

PRESBYOND- LASER BLENDED VISION

LBV is a non-linear corneal aspheric ablation profiles combined with micro-monovision to treat presbyopia in emmetropic, myopic and hyperopic patients

Laser Blended Vision: 9-in-1 Mechanism

- Monovision
- Vertex centration of spherical aberration
- Increased depth of focus
- Spherical aberration control [DOF without decrease quality of vision]
- Retinal image processing
- Neural summation
- Blur adaptation
- Neural suppression
- Multi-focality from epithelial lenticule

PRE REQUISITES

- Refraction & dominance testing
- Micromonovision testing
- Routine pre LASIK evaluation
- CRS Master planning software + MEL 80,MEL 90 (Carl Zeiss)

PRESBYOND® Laser Blended Vision is similar to monovision. It offers theopportunity to achieve freedom from glasses by combining thesimplicity and accuracy of Laser Vision Correction with the benefits ofincreased depth of field. It is an absolutely individualizedtreatment plan. This technique induces a controlled spherical aberration (to increase depth of field [12□. This micro-monovision strategy makes the imagedisparity from the two eyes smaller and the brain easily blends theimages together. A customized fusion of the twoimages for near and distance vision is created for each patient – this iscalled the "Blend Zone". Suitable from early 40's to late 50's

This new presbyopic profile is based on nonlinear changes in

asphericityThe dominant eye is mainly corrected for distance with a nominal target refraction of plano and the non-dominant eye is mainly corrected for near with a nominal target refraction of -1.50 D. As a result, the brain merges the two images, creating a blend zone, which allows the patient to see near, intermediate and far without glasses.

The important thing is to control the induction of spherical aberration to avoid increasing it above the neuro-adaptation tolerance threshold, which can cause loss of contrast sensitivity, night vision disturbances and can result in a topographic central island. To account for this, the non-linear aspheric ablation profile includes a pre-compensation factor for the induction of spherical aberration. This range was based on studies to understand the spherical aberration levels needed to increase depth of field [13, 14] and the 0.56-µm spherical aberration limit above which quality of vision might be subjectively affected as previously reported.[5]

Additionally, it can be used for emmetropic presbyopia as well as presbyopia accompanied by a wide range of refractive errors (published range: +5.75 to -9.00 D Intended Use SE range -8.00D and +2.00D, with maximum 2.00D cyl) including the simultaneous correction of cylinder. Performed as a bilateral simultaneous LASIK treatment, the bilateral procedure takes 10-15 minutes and recovers in a matter of a few hours. A further component of PRESBYOND is the increase in depth of field afforded by pupil constriction during accommodation: a component that persists even in eyes that have lost the ability to change crystalline lens power during the accommodative effort. The combination of controlled induced corneal aberrations and pupil constriction gives a significant increase in depth of field on the retinal image, albeit not a perfect image. In addition, intra-retinal and cortical processing and edge detection is the final component working in PRESBYOND: the pure retinal image, which is modified by spherical aberration, is further enhanced by central processing to yield the perception of clear and well-defined edges.

The final component of PRESBYOND relates to the epithelial thickness profile, which takes advantage of the fact that the epithelium remodels to compensate for any change to the stromal surface curvature.[16–20]

However, for lower levels of spherical aberration pre-compensation, a similar “multi-focal” change is being made to the stromal surface according to the spherical aberration component of the ablation, but the epithelial compensatory remodelling mechanism is able to fully mask this small stromal central island from the front surface topography – so the front surface topography appears normal. The result is an epithelial thickness profile overlying the stroma that looks and acts similar to a multifocal array lens due to the difference in refractive index between epithelium and stroma (1.401 vs 1.377).[21] This is then a very mild degree of induced point-spread function to supplement general increase in depth-of-field, and is something that can be tolerated by virtually all patients.

The multi-focality remains subsurface and cannot be seen on front surface corneal topography; it can only be seen by measuring the epithelial thickness profile. This method maximizes safety by eliminating the possibility of loss of lines, reduced contrast sensitivity, and reduced quality of vision as found in multi-focal corneal approaches

In summary, PRESBYOND draws on 6 mechanisms for its success as a procedure; depth of field is increased by:

1) A specific controlled increase in corneal spherical aberration

2) A sub-surface mildly multifocal epithelial thickness profile

3) Pupil constriction during accommodation affording further depth of field increase on the retinal image (cf pinhole effect)

4) Retinal and cortical processing for increasing contrast of the retinal image monocularly

5) An anisometropia small enough to be tolerated by over 95% of patients, which as a result of the above sphericalaberration induced increase in depth-of-field produces a blend zone and enable continuous distance to intermediate tonear vision between the two eyes

6) Central cortical processing of the spherically aberrated retinal image including neuronal gating and blur-suppression, butenabling simultaneous binocular vision (i.e. not monovision) and hence preserving stereo-acuity

PRESBYOND has excellent post-op

- Contrast sensitivity
- Stereopsis
- Negligible Crossblur
- Sharper & crisp uncorrected distance & near vision

The combination of induced asphericity and micromonovision with laser blended technique has had good visual and safety outcomes [12, 22–25], but the tolerance to micro-monovision may be inconvenient especially in patients with mild presbyopia, who are less tolerant to a larger degree of anisometropia than patients with advanced presbyopia [25]

MONOVISION

Presbyopia correction at the cornea can also be achieved with monovision, in which an intended anisometropia is induced, usually, the non-dominant eye is corrected for near vision, and the dominant eye for far vision, it depends on inter-ocular blur suppression. Good visual outcomes are achieved with this technique [26], but there is a loss of stereopsis which is related to the degree of anisometropia [27, 28], it is generally contraindicated in patients that need a good stereopsis to perform their daily activities such as airplane pilots [35, 36] or professional drivers [27, 29].

In short, achieving a multifocal cornea with stable and long term results remains a challenge [30, 8, 31, 32] to all refractive surgeons. The combination of different techniques for the correction of presbyopia (monovision, multifocality, asphericity modification) is a trending option [25] seeing that they benefit from the best qualities of each procedure

A prospective, non-comparative case series study was conducted in our hospital among 300 patients (600 eyes) with presbyopiain the age group 39 to 55 yrs (mean 47 yrs). The range of refractive errors was Myopia (-0.25 to-7.25DS), Hypermetropia (0.25 to 4DS) and Astigmatism between -0.25 to -2.75 DC,+0.25 to +1.5 DC. Target refraction was Plano for distance eyes (dominant eye) between -1.25 and -1.75 diopters (D) for near eyes based on age and micromonovision acceptance. (Non dominant eye:Target–1.5 DS (40%), –1.75 DS (53%),& –1.25 DS(in 7%))

All of them underwent routine preLASIK evaluation (Refraction, subjective acceptance, cycloplegic refraction for hypermetropic patients, slit lamp examination of anterior segment and fundus evaluation and Topography) along with Dominant eye testing and Testing for Micromonovision acceptance.

Laser Blended Vision – treatment planning was done and was integrated into the CRS-Master – MEL 80 platform.Standard LASIK procedure was done with Microkeratome: AMADEUS II(Zeimer, Switzerland). The flap had 9mm diameter, 120 micron thickness with nasal hinge. This was followed by ablation with Excimer: Mel 80 flying spot laser (250Hz) (Carl Zeiss Meditec, Germany)Post operatively they were treated with Prednisolone Acetate 1%, 0.5%moxifloxacin, 0.5%CMC. Follow up was done on day 1, 1 wk, 1 month, 3 month, 6 month, 1 yr, 2yr. 24 months minimum follow up was done for all patients.

92% of eyes achieved Spherical equivalent correction within -0.50 D and 100% of eyes within -1.00 D at 1 year follow up. Monocular uncorrected distance visual acuity was 20/20(6/6) at least in 70%, 20/32(6/9) at least in 98%. Binocularly 80% read 6/6 and 100% read 6/9. Binocular uncorrected near visual acuity was N8 in 3% and N6 in 97%of patients. All patients had a satisfactory intermediate vision (n6) Binocular distance vision subjectively was better than uniocular distance vision in significant number of people (60%) A higher number of patients read 6/6 binocularly (80%) than when checked through the dominant eye alone (70%). None of the LASIK LBV patients in our series needed enhancement procedures.

Adaptation: Most patients adapted well by the third month. Myopes beyond 42 years of age adapted very easily(1wk to 1month). Hyperopes, emmetropicpresbyopes, young patients (less than 40 years) took 2-3 months, to completely adapt. Only 6 patients had occasional adaptation issues, i.e. cross blur for distance, one patient reported confusion while reading fine print after this period which improved with lubricants. Night vision symptoms: 8 patients in 300 complained in 1st month, none at 3 months. None of the eyes lost more than ½ snellens line of vision when compared to preop corrected distance visual acuity.

CONCLUSION

There have been significant developments in surgery for presbyopiaover the last decade achieving relatively good outcomes but each modality has its own advantages and disadvantages and sometimes compromises. In fact the search for the restoration of true accommodation remains a challenge. Technological advancements have certainly moved surgical restoration of accommodation from a theoretical concept more into real ophthalmic practice, but much work still remains. The ophthalmologist should decide which surgical management is the best choice for each patient. The most important recommendation is to help patients to set realistic expectations, and together with the subject evaluation, predict the effectiveness of surgery.

WHAT IS THE BEST OPTION?...

TREATMENT	DIST VISION	INTERMEDIATE VA	NEAR VISION	NIGHT DRIV PROB	CONTRAST	ADAPTATIO N	SAFETY
MF IOL	FAIR	NOT SATISFACTORY	GOOD	YES	REDUCED	SLOW	FAIR
CORNEAL INLAYS	GOOD	GOOD	GOOD	YES	REDUCED	GOOD	FAIR
PRESBYLASIK	FAIR	GOOD	GOOD	YES	REDUCED	SLOW	FAIR
SUPRACOR	FAIR	GOOD	GOOD	YES	REDUCED	SLOW	FAIR
PRESBYOND	GOOD	VERY GOOD	GOOD	NO	NO CHANGE	FAST	GOOD

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