

PRESBYOPIA TREATMENT: A REVIEW OF THE CURRENT SCENARIO

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Abstract:

One of the most important causes of visual difficulty for near is presbyopia. It is an important and the most common cause in adult population. IT has been seen that presbyopia accounted for 71.8%, cataract and pterygium accounted for 16.5 and 2.5% of total cases of visual impairment for near respectively. This holds for the entire population globally. Presbyopia is an ever-increasing global problem affecting over a billion worldwide. The increase in the number of the aging population has prompted health care professionals to find ways to manage the situation with various non-surgical and surgical means effectively. The current article discusses these surgical and non-surgical means of presbyopia correction.

Keywords: Presbyopia, Accommodation, Ciliary Body, Spectacles, Contact Lens, Inlays, Lasik.

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INTRODUCTION

Presbyopia Treatment: Current Scenario

Presbyopia is age-related progressive decrease in the ability to focus near objects i.e. insufficiency of accommodation. It is inevitable and irreversible but not a pathological condition. It is usually seen after 40 years of age. However, hypermetropes present at younger age as compared to myopes. They present with the symptoms of near vision difficulty like inability to read, thread a needle or sometimes with asthenopic symptoms. The prevalence of presbyopia was 1.8 billion globally in 2015 which is expected to rise to approximately 2.1 billion in 2030. [1]

Pathophysiology

Accommodation occurs due to well-orchestrated actions of ciliary muscle (CM)

and iris sphincter, resulting in convergence and changes in the shape and position of the lens. The parasympathetic cholinergic stimulation causes the contraction of the ciliary muscle and iris sphincter leading to miosis, increase in depth of focus and the shape and position of the lens both to change resulting in accommodation[1,2]. Presbyopia develops when this process is interrupted due to ageing process at various level like decrease in elasticity of lens, loss of ciliary tone, decreased distance between ciliary muscle and lens equator.[1,3] Theories supporting these hypotheses are Helmholtz theory, Schachar theory and Catenary theory. According to the Helmholtz theory, which is the most widely accepted, contraction of the ciliary muscle causes relaxation of the zonular fibers leading to the increase in the curvature of anterior and posterior lens surfaces resulting in an increase in the net

power of the lens, causing the change in focus of the eye from far to near.

Treatment

1. Spectacles - spectacles have been the time tested and most commonly adopted treatment modality.

a. Single vision reading glasses: best suited for those who have no significant distance refractive error, only near glasses is required.

b. Bifocals: it is a better choice for them who require both distance and near correction. Here upper half is for distance correction and lower half for near. However such glasses have the disadvantage of image jump from distance correction to near correction.

c. Trifocals: it consists of three power lenses, upper for distance, middle for intermediate and lowers for near correction.

d. Progressive addition lenses (PALs): in this the power gradually progresses from distance correction to near correction. Hence there is no image jump and better cosmesis as there is no demarcation line. However it is not suitable for those who have high add on or who have high anisometropia.

e. Monovision: it is the optical state of patient in which one eye is corrected for distance and the other for near. It can be achieved with single vision spectacle in which one lens focuses for distance and the other for near. However it is rarely used in preference to the bifocal or multifocal spectacles.

2. Contact Lenses:

Options for presbyopic contact lenses include

a. Monovision: monovision with contact lens is achieved by correcting the dominant eye for distance and the non-dominant eye for distance.

b. Modified Monovision: here patient is given single vision correcting lens in one eye and bifocal correction in the other eye or

both the eyes are corrected with bifocal lens with different near vision add.

c. Bifocal: bifocal contact lens

d. Multifocal contact lenses: they are designed for correcting near vision, distant vision along with the intermediate distance vision

3. Surgical Interventions

A. Cornea based procedure:

Adding (inlays): intracorneal inlays are a type of intrastomal implants made up of hydrogel material having permeability similar to corneal stroma. They are implanted in non-dominant eyes under the corneal flap created either by LASIK or Femtosecond laser created pocket. The pocket technique has the advantage of preserving the corneal nerves and hence the corneal sensitivity. The advantages of these inlays include ease of implantation and the procedure being minimally invasive and reversible. They are of three types namely corneal reshaping inlays: they reshape the anterior curvature of cornea to hyperpolate with increased power and thus produce multifocal effect. [16] It is available as Raindrop (ReVision Optics, Lake Forest, CA, USA). It is made up of biocompatible hydrogel material which has 80% water. It is 2mm in diameter, 10 μm thick at the periphery and 32 μm at the center. [15] It does not have any refractive index. Corneal thickness of 500 μm or thicker is a prerequisite. It is placed in the nondominant eye at a depth of 150 μm with a residual stromal bed thickness of 300 μm and is aligned to the first purkinje reflex over the center of the light-constricted pupil [17].

Small aperture inlay: it works on the principle of pin hole effect to improve the depth of focus for near and intermediate distance without affecting the distant vision [18,19]. KAMRA Vision (AcuFocus Inc., Irvine, CA, USA) is a small aperture inlay with specification of 3.8mm diameter, 5 μm thickness with a central 1.6-mm aperture in its latest design (ACI 7000PDT). It also has

8400 microperforations of diameter ranging from 5 to 11 μm to allow nutritional flow through the cornea. [19,20]. It is the most widely used inlays.[20] It is made of polyvinylidene fluoride.

Refractive inlays: it utilizes the principle of bifocal optics to separate the distance and near focal points by altering the refractive index. Refractive inlays available in market are Flexivue Microlens (Presbia Cooperatief U.A., Amsterdam, the Netherlands) this is a hydrophilic acrylic refractive inlay of 3.2mm diameter and 15-20 μm edge thickness (depending on the add power). It has a 1.8mm central plano zone with increasing rings of higher power in periphery ranging from +1.25 D to +3.00 D in 0.25-D increments. A central opening of 0.15 mm facilitates the transfer of nutrients and oxygen through the cornea [16, 22] Icolens (Neoptics AG, Hünenberg, Switzerland) it is a hydrophilic copolymer of hydroxyethyl methacrylate and methyl methacrylate inlay of 3mm diameter and edge thickness of 15 μm with a central 0.15 mm hole for nutrient flow [20,21]. It has a bifocal design with a peripheral positive refractive zone for near vision and a central zone for distance vision.[21] Presbyopic correction ranging from +1.5D to +3D in 0.5D steps can be achieved with this inlay.

Subtracting (laser based):

Mono vision: monovision with the help of excimer laser is done by inducing intentional anisometropia by correcting one eye usually the non-dominant eye for near and the other eye for distance (the dominant eye) with the help of excimer laser.[26].The success of mono vision is depends on the mechanism of interocular blur suppression.

Prebylasik: It is the process of achieving multifocality by excimer laser ablation. In peripheral prebyopylasik, the peripheral cornea is ablated to create negative peripheral asphericity. Thus the the mid-peripheral cornea for near vision and central cornea is for distance vision eg, Nidek Advanced Vision Excimer Laser; (NIDEK,

Gamagori, Japan).In central presbylasik, the central area is ablated for near vision and the periphery for distance vision (eg, Supracor, Technolas Perfect Vision GmbH, München, Germany) and Pulsar (CustomVis, CV Laser, Perth, Australia).

PRESBYOND: It is an optimised laser treatment method to improvise the conventional monovision. Here the dominant eye is ablated as such that it is corrected for distance to almost plano and the non-dominant eye is treated to achieve mild myopia of about -1.5D for near visual acuity. E.g. Presbyond Laser Blended Vision (Carl Zeiss Meditec, Jena, Germany). Presby MAX software introduced by SCHWIND eye-tech-solutions (Kleinostheim, Germany) This is a biaspherical cornea modulation technique, based on the creation of a central hyper positive area for near vision and leaving the peri- central cornea for distant vision [25].

Moulding:

Conductive Keratoplasty: Conductive keratoplasty (CK) is a safe, effective and non-ablative technique that uses radiofrequency energy (0.6 W with a 0.6-s treatment time) [24] to produce thermal effect causing shrinkage of corneal collagen leading to change in the contour of cornea making it more steeper with higher refractive power. However, its effect regresses over time. [23]

Intracor: It is a recently developed procedure that delivers femtosecond laser energy (TECHNOLAS by Technolas Perfect Vision GmbH, Munich, Germany) to delivers laser pulses in a customizable pattern entirely within the stroma, from the posterior to the anterior stroma without affecting the endothelium or Bowman's layer. This creates a hyperprolate multifocal cornea to treat presbyopia. It has advantage of providing stable visual acuity but it reduces mesopic contrast sensitivity and increases glare sensitivity [27].

b. Sclera based procedure:

Scleral procedures are based on Schachar's theory of accommodation which states that increased equatorial zonular tension on lens causes accommodation, and thus, any procedure that increases this tension by increasing the distance between the lens equator and the ciliary muscle should reverse presbyopia [11]. These treatment approaches can restore true accommodation to the presbyopic eye.

LAPR (Laser Assisted Presbyopia Reversal) - it was invented by Lin (US patent 2000). SurgiLight and Ace Vision Group are the two companies that carried out the clinical trial with similar results. Both of them used Er: YAG for scleral ablation with ablation depth of >80% of scleral thickness. SurgiLight used 8 incision lines whereas Ace Vision Group used 36 dots pattern in the oblique quadrant of the eye to create ablation. This method is safe and effective but has disadvantage of being invasive and a slow procedure.

Scleral Expansion Bands: The VisAbility Micro-Insert scleral implant (Refocus Group, Dallas, TX, USA), is the only scleral implant with the CE mark. Even though the early results of its use in clinical trials seem promising, it is associated with substantial risks. Most notable being the Anterior segment ischemia (ASI) due to mechanical compression of blood vessels. Other possible complications being the subconjunctival haemorrhage and erosions implant related infection, and endophthalmitis.

c. lens based procedures:

Pseudophakic Miol: multifocal IOL following cataract surgery or clear lens extraction using the principle of multifocal CL has been used with excellent clinical outcome. [1]

Refractive Miol: it has typical circular refractive zones wherein two different powers are integrated. Different zones having different effective aperture image, quality depends on pupillary size and the accommodation reflex. Examples include The ReZoom (Abbot Medical Optics

(AMO), Irvine, California, USA), The M-flex MIOL (Rayner IOLs Limited, Hove, UK).

Diffraction Miol: it is based on the principle of diffraction which states that light slows down and changes its direction on encountering any obstacle.[2] on the lens surface there are microscopic steps i.e. diffraction zones. As the light falls on these steps it gets diffracted towards the distant and near focal points depending on the step height and wavelength. It is said to be apodised when there is gradual reduction in diffractive step heights from centre to periphery and non-apodised when the height is uniform. Examples include the ReSTOR (Alcon Lab, Fort Worth, Texas, USA) (apodised) and Tecnis Multifocal (Abbott Medical Optics, Santa Ana, California, USA) and AT LISA 809 IOL (Carl Zeiss Meditec, Hennigsdorf, Germany) (both non-apodised)

Extended depth of focus IOLs: a newer IOL designed to overcome the shortcomings of multifocal IOLs. It uses diffractive optics to elongate the focal length and correct for chromatic aberration. Thus improves the near and intermediate vision without much of glare and halos. TECNIS Symphony IOL (Abbott Medical Optics/AMO, Inc. of Santa Ana, California, Now Johnson-Johnson Vision) and The AcrySof™ IQ Vivity™ Extended Vision Intraocular Lens (IOL) are two such IOLs which are FDA approved and have shown excellent results in terms of patient satisfaction. [28]

Accommodating IOLs: they are designed to mimic the normal crystalline lens. Accommodation is achieved by change in axial position e.g. Single Optic Crystallens HD (Bauch & Lomb) change in shape or curvature of IOL e.g. FluidVision (Powervision, Inc), Nulens (Dyna Curve) or by change in refractive index e.g. Lumina (Akkolens). These IOLs are compressed by the ciliary muscle contraction during accommodation pushing the optic to move to opposite direction increasing its dioptric power and as the muscle relaxes the optics reverts back to its original position.

4. Pharmacological treatment: It is based on the principle of pin hole i.e decreasing the size of the pupil increases the near visual acuity by increasing the depth of focus. However inducing miosis is associated with the risk of decreased vision quality especially in dim light and myopic shift compromising the distant vision. Some of the agents tried for pharmacological treatment of presbyopia are mentioned below.

A. PRX (100): it contains combination of aceclidine and tropicamide which has been developed by 'Presbyopia Therapies'. Tropicamide is an anti-muscarinic agent which causes mydriasis and aceclidine is a muscarinic agonist similar to pilocarpine and carbachol but is less potent. This drop causes miosis without the typical accommodative effect, thus increases the focus depth and provides improvement in near vision without impairing the distance vision with the pinhole effect [5]

B. EV06: it is an ophthalmic solution containing lipoic acid choline ester 1.5%. EV06 is a prodrug which penetrates the cornea and metabolizes to lipoic acid and choline and after catabolism, it increases lens elasticity by decreasing the number of protein-disulfide bonds and making the crystalline lens more elastic and softer via natural un-crosslinking i.e it reverses the lens hardening caused due to increased protein sulfhydryl group oxidation which forms protein cross-links in the lens fibres.[3,4]

C. AGN-199201: it is an ophthalmic solution containing Oxymetazoline, a alpha adrenoceptor agonist, (Allergan, 2018). Its use has shown an improvement of at least 2 lines in uncorrected near visual acuity in upto 70% of patients. [10]

D. PRESBIDROPS: PresbiDrops contains a combination of a parasympathomimetic agent with a NSAID in an oil-based formulation. E. Vejarano Drops: It includes pilocarpine 0.247%, phenylephrine 0.78%, polyethylene glycol 0.09%, nepafenac 0.023%, pheniramine 0.034% and naphazoline 0.003% maintained the

stimulation of the contraction of the CM and the physiological pupil diameter variation [7].

F. Presbyeyedrops: this eye drop is a combination of two parasympathomimetic agents (unknown exact active ingredients and a NSAID). Improvements in both UDVA and UNVA have been reported with the use of this drop. [8]

G. Liquid Vision drops: provide a temporary presbyopia-correcting therapeutic effect designed to last five hours or longer. Its phase IIb trial is continued. Liquid Vision eye drop contains aceclidine (a miotic) and tropicamide (a cycloplegic) to provide a 'super pinhole' effect and moderate accommodation. Aceclidine is used for creating the pinhole effect but by itself, this creates strong accommodation, including ciliary spasm and distance vision blur. Tropicamide reduces accommodation. Mutual effect between these two drugs improves both near and distance vision simultaneously. [9]

5. Ciliary Muscle Electrostimulation (Ocufit)

the bilateral pulsed electro stimulation (2sec on and 6 sec off) of the ciliary muscle on 4 occasions at 2 week intervals using a polycarbonate scleral contact lens equipped with four micro electrodes at the four quadrants, 3.5 mm from the limbus (corresponding to the ciliary body region) to stimulate the ciliary muscle so as to increase its potency to overcome the ageing process is done [6]

6. Preventive Measures

The process of ageing is inevitable so is presbyopia. However there are certain conditions associated with early onset of presbyopia which can be addressed to halt this like diabetes mellitus, cardiovascular diseases, myasthenia graves, anaemia, vascular insufficiency, multiple sclerosis etc. Certain drugs like alcohol, antipsychotics, and diuretics, antihistaminic are also

implicated in causation of premature presbyopia i.e. before 40 years of age.

Conclusion:

Presbyopia cannot be escaped but updated knowledge and skill can definitely improve the quality of life. Various treatment modalities are upcoming some are well established and some are under clinical trials. They all need patient acceptance towards some compromises that might happen in the quality and flexibility of vision offered at different distances with the newer modalities until an ideal and unique treatment that restores true accommodation is developed.

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