

Corneal Surgical Approach in the Treatment of Presbyopia

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Abstract

Purpose: The aim of this paper is to outline the various corneal approaches to the treatment of presbyopia and discuss their effectiveness

Method: Most corneal surgical procedures involve LASIK. Supracor uses a progressive ablation profile to provide an aberration optimized smooth transition from distance to near correction. In presbyLASIK a hyper positive area is created at the centre of the cornea for near vision and the periphery provides a focus for distance. The Intracor procedure is an intra-stromal treatment using a femto-second laser. It creates concentric rings with the stroma. These bring about central steepening of the cornea. Monovision corrects one eye for distance and the less dominant eye for near. Conductive keratoplasty uses heat generated by high radio frequency current to alter the corneal stroma. Corneal small aperture implants or inlays are inserted into the cornea through a pocket created by femto-second laser to improve the near and intermediate vision.

Results: Supracor offers the best prospect but the high retreatment rate is a major drawback. Intracor and corneal inlays offer the best hope for elimination of reading glasses but reduction of distance vision, loss of binocularity and reduction of the effect overtime limit their use. Monovision for a selective group of patient is still the best alternative.

Conclusions: There is no ideal corneal surgical approach to presbyopia. The future may involve more than one approach, perhaps a corneal approach for patients under 50 and a lens solution for older patient. The ideal procedure and best outcome is still some way off.

Keywords: Presbyopia; Corneal surgery; Lasik

Introduction

Presbyopia commonly occurs in people in their mid-forties. The lens thickens and broadens and it is part of a naturally ageing process. The muscles of the eye can no longer change the slope of the lens to focus on near objects. This is why most people eventually develop the need for reading glasses or bifocals. Reading glasses are inconvenient, they make patients feel older and patients no longer see clearly again with both eyes. It remains the single biggest challenge in refractive surgery. It is the last great frontier and the most complex. There were over one billion people estimated to have presbyopia in 2005 and this will increase to two billion by 2050 [1]. Therefore, there is a large incentive to succeed. However, presbyopia is a moving target with accommodation, a dynamic physiological process and difficult to replicate.

There are many different techniques available and they make it easier to correct presbyopia but all have limitations and involve compromise. Accommodating techniques include accommodating intra ocular lenses (IOLs) and scleral expansion procedures [2]. The eyes natural lens is replaced by an advanced artificial lens. It corrects presbyopia and eliminates the formation of cataracts into the future. It corrects near sightedness, farsightedness and astigmatism at the same time [3]. Pseudo accommodative techniques include multifocal IOLs, corneal inlays, conductive keratoplasty, monovision, excimer laser

surgery, excimer multifocal ablation, intra stromal femto second laser procedures. With multifocal IOLs the eyes natural lens is replaced by a multifocal artificial lens and this eliminates the need for glasses at near and distance.

Techniques

A corneal approach is attractive to many surgeons, it avoids intra ocular procedure and (LASIK) laser *in situ* keratomeleusis is a familiar technique that is long established and less invasive [4]. Presbyopia laser vision correction like all LASIK surgeries is an ambulatory procedure you walk in and walk out afterwards.

SUPRACOR (Technolas Perfect Vision GmbH) uses a progressive ablation profile to provide an aberration-optimised smooth transition from distance to near correction using LASIK [5]. Distance correction is achieved by a zyoptic tissue saving algorithm in hyperopic eyes. A central near addition is ablated to correct near vision and the paracentral cornea is used for distance vision.

It should be used in patients who need at best +1.75 D of near addition, patients in their late forties and the initial manifest refraction should be between +1 D and +3 D of hyperopia and astigmatism up to +1 D. Cycloplegic refraction should not differ by more than +5 D. Patients with anisometropia or amblyopia should be avoided. It has advantages over other techniques. It is a LASIK procedure and enhancement procedures are possible. Spherical aberration is reversed

in from positive pre-operative to negative post-operative level to give pseudoaccommodation. In our six month outcomes and this has also been confirmed at 12 months follow up 93% of patients were fully independent of reading glasses. Six percent lost two or more lines of corrected vision; however, 22% of patients required retreatment [6]. There were no serious intra operative or post-operative complications. Loss of lines of CDVA is a potential drawback of many presbyopic procedures, similar and greater losses of CDVA have been reported in other corneal pseudoaccommodative procedures. Centration of the treatment is vital as decentred ablations cause unwanted aberrations. Enhancement is easily performed.

In presby LASIK a hyperpositive area is created at the centre of the cornea for near vision while the periphery provides the focus for distance. Two generations of presby LASIK have emerged. The first generations includes procedure based on refractive data. This involved central hyper positive multifocality and peripheral hyperpositive multifocality. A further improvement was developed where in addition to ablations profile corneal geometry and wavefront data were included. The initial results on this first generation presbyLASIK were encouraging [7-9]. Presbymax technology uses the Amaris Excimer Laser from Schwind. Another technique is laser correction that combines two mechanisms, inducing spherical aberrations to increase the depth of field and anisometropia in the non-dominant eye. The intention of the technique is use optimized ablation profile to provide good quality vision [10,11].

The IntraCor procedure is an intra-stromal treatment for presbyopia for near. Using the Femto second laser Technolas 520 F, a series of concentric rings within the stroma are created [12]. The rings lead to a localized change in the biomechanical properties of the stroma to bring about a central steepening of the cornea to treat presbyopia Figure1. Patient selection is important. It is a unilateral procedure in non-dominant eyes. The subjective spherical equivalent is in a range of +0.50 - +1.00 D and cylinder of 0.5 D or less. The corneal pachymetry at least 500 μ and K-readings between 39-48 D.

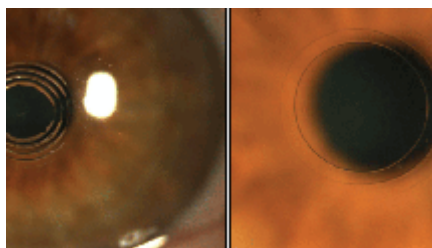


Figure 1: Types of corneal procedures, SupraCor, IntraCor, PresbyLASIK, Monovision, Inlays.

In 2010 we conducted a prospective randomized study on a group of presbyopic patients recruited from our hospital population. Ninety percent are glasses free at five years and in ten percent it had no effect. The problem encountered was that further surgical option was limited in this group of patients. Five percent of patients had glare but this was not a significant problem for the affected patients. We encountered no other problems and patient satisfactions were over ninety percent.

Barraquer first proposed corneal implants to correct ametropia. The rationale was to implant an inlay to modify the shape and change the refractive power of the cornea [13,14]. There were serious complications with the first surgeries, including corneal necrosis,

epithelial and stromal opacification and vascularization, all in the main due to corneal nutrition [15]. Advances in laser technology, biometrical compatibility renewed surgeons and pharmaceutical company's interest in the technology. There are three different types of Inlay currently being used, space occupying small aperture and refractive inlay. We have performed one of the initial trials on the refractive inlay. It is called the Icolens (Neoptics, Switzerland) and is a micro lens 3 mm in diameter with central hole of 150 μ m to facilitate midrient Flow Figure 2. It has a thickness of 15 μ m and is made of copolymer of HEMA and MMA (hygroic properties: The lens has a bifocal design central zone for distance and a peripheral positive refractive zone for near. It is preloaded and inserted into a 3mm pocket of the cornea at a depth 50% of thickness Figure 3. 6% lost one to two lines of uncorrected distance vision but 90% gained binocular uncorrected distance vision. In dim light or prolonged reading patients still required reading glasses. 10% of patients required explantation soon after or within a few years because they felt no appreciable benefit. It is a reversible procedure and is free of any other side effects.

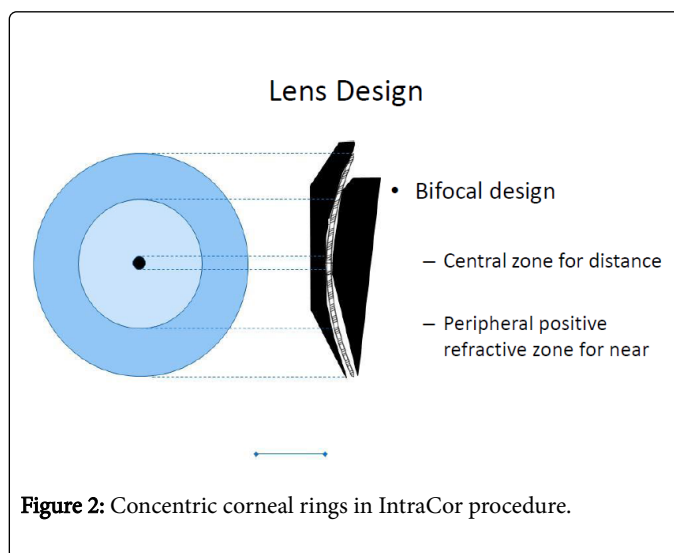


Figure 2: Concentric corneal rings in IntraCor procedure.

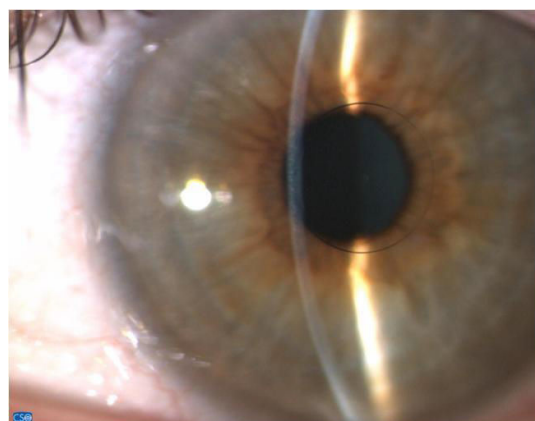


Figure 3: Corneal inlays.

The Kamra small-aperture Intra corneal inlay (Acufocus Inc) is designed to increase the depth of field based on the principle of small aperture optics to restore near and intermediate vision without compromising distance vision [16-18]. Like the Icolens the Kamra

Inlay is reversible. It has the potential to be used as a combined refractive procedure [19]. It has recently received approval from the US food and drug administration (FDA) for treatment of plano presbyopia.

Conductive keratoplasty is a temporary treatment for presbyopia. It uses heat generated laser radio frequency energy to change the shape of the cornea. A special probe is used to apply the radio frequency energy to a number of treatment areas around the cornea. Overtime the cornea returns to its original shape and the treatment wears off.

Monovision is a well-established method used for presbyopic correction with one eye corrected for distance vision and the other eye for near vision. It has been used for some time using contact lenses with a success of between 60%-80% [20]. In 2007 the US food and drug administration (FDA) approved laser in situ keratomileusis (LASIK) treatment of monovision. The dominant eye is corrected for distance vision and the non-dominant eye for near vision. The dominant eye is better for driving, watching TV and less likely to induce strabismus. Monovision depends on intraocular blur suppression and patients who do not have a strong sighting preference level can stand intraocular blur suppression and have more success with monovision [21,22]. Pre surgery trial is important and if it works with contact lenses then laser will give same outcome. Patient selection is also important, patients unsuitable include pilots, professional drivers and those who spend most of their day on computers or reading for a living. It will reduce contrast sensitivity and stereo acuity. A difference of -1.50 to -1.75 D works best. An important factor is that the distance eye is made emmetropic and one has to correct astigmatism.

Discussion

Presbyopia correction is still a major challenge in spite of all our advances in refractive and lens technology. Some regard accommodating and multifocal IOLs as the future. However, they too are not the panacea. The many different designs are clear proof of their work in progress. In our practice we see an increasing number of unhappy patients for second opinions because of poor intermediate vision and problems with night driving. The ideal corneal approach is a long way off if ever and all the current techniques have drawbacks, as reduced light striking the retina from any focal length reduces contrast sensitivity. Then there is the need for adaptation particularly in a multifocal cornea. Many patients particularly females have ocular surface dryness which may persist well after surgery and it can be permanent.

Our best long term outcome resulted from IntraCor but in 10% of patients derived no effect and in contrast to other techniques it was not possible to alter the corneal contour. The procedure was abandoned by the Technolas with no attempt to improve the technology. So IntraCor has gone the same route as conductive keratoplasty but for different reasons. Corneal Inlays should be the ideal choice. The surgical procedure uses laser depth and creation of the corneal pocket is precise. The current Inlays are more compatible with corneal nutrition. They can be exchanged and it is the only refractive procedure that is reversible. However, it can only target a small population of presbyopes. Our experience is disappointing in terms of outcome. We fear that it will also go the same way as IntraCor and conductive Keratoplasty. Monovision reduces contrast sensitivity and there is a worsening of stereocopy put it still remains the treatment of choice in a selective number of patients. It is difficult to compare any of the

techniques described. They have a different surgical approach. Supracor was the great hope but has not lived up to expectations.

Therefore, conquering presbyopia remains the current challenge. All of the available techniques both corneal and intraocular have significant drawbacks. The solution may be in more than one procedure. Perhaps a corneal approach up to the age of fifty and lens approach after this. Our search for the Holy Grail in presbyopia is some way off.

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