REVIEW OF THE RECENT ADVANCES IN PHAKIC INTRAOCULAR LENSES TO CORRECT HIGH ERRORS OF REFRACTION

Essay

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List of Abbreviations

AC	**Anterior chamber**
AC PIOL	**Anterior chamber phakic intraocular lens**
CLE	**Clear lens extraction**
ICL	**Implantable contact lens**
IOL	**Introcular lens**
IOP	**Intraocular pressure**
LASIK	**Laser insitu keratomileusis**
PC	**Posterior chamber**
PC PIOL	**Posterior chamber phakic intraocular lens**
PIOL	**Phakic intraocular lens**
PDS	**Pigment dispersion syndrome**
PMMA	**Polymethyl methacrylate**
PRK	**Photorefractive keratectomy**
PRL	**Phakic refractive lens**
LRIs	**Limbal relaxing incisions**

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CHAPTER 1

Demographics of Refractive Surgery

MYOPIA

Definitions

While there is some variability in terminology found in the literature, the following definitions will be used to stratify levels of myopia: low (less than -5.00 diopters D), moderate (-5.00 to -10.00 D), and high (greater than -10.00 D). Visually significant myopia is considered to be -1.00 D or greater. These specific stratifications are chosen because they are most representative of those used in the literature. In addition, the efficacy of different refractive techniques varies with attempted correction. In general, photorefractive keratectomy (PRK) provides effective results for patients with low myopia while laser in-situ keratomileusis (LASIK) is effective for low and moderate myopia. Phakic IOLs will likely address high myopia (Hamilton et al., 2004) .

Prevalence

The distribution of levels of myopia is highly variable among different races and ethnic groups. In general, the prevalence of myopia tends to be higher among more developed populations. The prevalence of myopia is estimated to be 70% to 90% in Asia, 30% to 40% in Europe and the Americas, and 10% to 20% in Africa (Saw et al., 1996).

Myopia is more prevalent in younger patients. More than three-fourths of those individuals aged 18 to 24 years that wear corrective lenses have low myopia. Of patients presenting for myopic refractive surgery, however, the numbers are skewed toward higher levels of correction. McCarty et al compared the stratified prevalence of myopia in the general population of Melbourne, Australia with that of individuals presenting for refractive surgery. The study found that while only 2% and 0.4% of the general population had moderate and high myopia, respectively, 42% and 13% of those patients presenting for refractive surgery had moderate and high myopia, respectively. In other words, moderate myopes were ten times more likely to present for refractive surgery than low myopes, and high myopes were sixteen times more likely to present for refractive surgery than low myopes. A similar result reported by Ucakhan et al found that 17% of patients presenting for refractive surgery at a center in the United States had myopia of -6.00 D or greater compared to an estimated 2% prevalence in the general population (Ucakhan et al., 2000).

HYPEROPIA

The following definitions will be used to stratify levels of hyperopia: low (less than +3.00 D) and high (greater than +3.00 D). Again, these stratifications are chosen because they are most representative of those used in the literature. In addition, the efficacy of different refractive techniques varies with attempted correction. In general PRK, LASIK, and conductive keratoplasty (CK) are effective for low hyperopia. Phakic IOLs will likely address high hyperopia (Hamilton et al., 2004).

Prevalence

In the adult population, low hyperopia remains largely silent clinically until the fifth decade due to the accommodative ability of the crystalline lens (Friedman et al., 2003).

REFRACTIVE SURGICAL PROCEDURES FOR MYOPIA:

Refractive surgical procedures available to treat myopia include LASIK, PRK, and its variants (laser subepithelial keratectomy, otherwise known as LASEK or Epi-LASEK), intracorneal ring segments, clear lens extraction, and phakic IOL implantation.

1. Laser In-Situ Keratomileusis

There is little disagreement that LASIK affords the highest level of comfort, quickest recovery, and most stable, predictable outcome for low and moderate myopia (El-Maghraby et al., 1999).

Efficacy and predictability decrease, however, when treating high myopia with LASIK (El-Dansoury et al., 1997).

The incidence of decreased contrast sensitivity and increased glare and halos appears to be significantly higher with large myopic corrections (Holladay 1995).

This decrease in visual function is likely related to alteration of the corneal asphericity following myopic laser ablation in which the natural prolate shape (ie, steep in the center, flat in the periphery) of the anterior surface is converted to an oblate shape (ie, flat in the center, steeper in the periphery) (Holladay et al., 1999).

Oshika et al demonstrate a positive correlation between amounts of induced coma-like and spherical-like aberrations and increasing attempted correction (Oshika et al., 2002).

The study also shows a positive relation between eyes losing two or more lines of best corrected acuity and level of induced coma-like and spherical-like aberrations. Several studies report losses of two or more lines of best-corrected visual acuity in 3% to 5% of highly myopic eyes treated with LASIK. (Hersh et al., 1998).

At 6 months, 58% gained one or two lines of best-corrected visual acuity. This is likely attributable to the relative magnification achieved by elimination of spectacle correction in high myopia and the preservation of natural corneal asphericity (Applegate and Howland 1993).

Corneal thickness becomes a limiting factor with increasing correction, as there appears to be a correlation between risk of keratectasia and decreasing residual bed thickness following LASIK (Ou et al., 2002).

While the etiology of keratectasia is not fully understood,it is generally accepted that ablating below a minimum residual bed thickness increases risk. The value of 250m has been proposed as a threshold beyond which ablation should not proceed (Seiler et al., 1998).Unfortunately, even this number may not be sufficient in every case, as evidenced by reports of keratectasia following shallow ablations with thicker residual beds (Amoils et al., 2000). In some of these cases, forme fruste keratoconus as seen on topography may contribute to the development of keratectasia (Seiler and Quurke 1998).

In a recent study by Hori-Komai et al examining the reasons why patients presenting for refractive surgery did not undergo LASIK or PRK, 25% of 2784 consecutive patients did not undergo either procedure. Nearly 30% of the patients that did not have surgery had either high myopia (>-12.00 D) or had insufficient corneal thickness (Hori-Komai et al., 2002).

The concern over adequate residual bed thickness, coupled with the lower predictability of LASIK refractive outcomes at higher corrections, leads to the additional issue of potential "nonenhanceability." The high myope is more likely to require an enhancement than the low or moderate myope but also may not have enough tissue remaining to safely perform additional ablations. In these situations, a procedure that does not remove corneal tissue and does not alter the natural prolate shape of the anterior corneal surface, such as phakic IOL implantation, offers an attractive solution (Hamilton et al., 2004).

2. Photorefractive Keratectomy

PRK, which has been performed for more than a decade, has proven extremely effective in treating low myopia, demonstrating high levels of safety, efficacy, stability, and predictability (Stevens et al., 2002).

PRK holds particular appeal for patients with corneas too thin for LASIK due to inadequate residual bed thickness. The absence of a flap typically adds 100 to 150 m to the treatable stromal bed in PRK. While LASIK became dominant in the late 1990s due to its faster recovery and improved patient comfort (El Danasoury et al., 1999).

PRK has experienced a resurgence of interest recently due to the introduction of wavefront-guided laser treatments and the notion that the microkeratome pass and flap healing in LASIK may introduce additional optical aberrations (Pallikaris et al., 2002).

PRK, even more so than LASIK, however, performs less impressively when treating moderate to high myopia (Krueger et al., 1995).

The likelihood of significant regression of treatment effect increases significantly with higher corrections, possibly due to epithelial hyperplasia (Lohmann et al., 1999).

In addition, stromal wound healing can lead to subepithelial haze formation, with more severe haze developing with higher corrections (Tang and Liao 1997).

The haze, which can decrease visual acuity directly in its more advanced manifestation, is thought to closely relate to refractive regression (Siganos et al., 1999).

These two factors— regression and subepithelial haze— dramatically reduce PRK efficacy in treating high myopia. One study found efficacy of only 30% for achieving 20/40 or better and 4% for 20/20 or better uncorrected acuity at 6 months in the high myope (Carson and Taylor 1994).

Issues describing decreased visual function resulting from induced higher-order aberrations, which were discussed in the LASIK section, apply to high myopia PRK treatments as well. However, with the lack of a flap, PRK may introduce fewer aberrations if the healing process can be adequately controlled when treating large corrections.

In particular, the use of mitomycin C (MMC) may be advantageous to reduce subepithelial haze formation in moderate and high myopic treatments using PRK (Majmudar et al., 2000).

A recent prospective, randomized study compared the 6-month uncorrected visual acuity (UCVA) between eyes with moderate myopia treated with and without MMC. A statistically significant difference was found in UCVA at 6 months at both the 20/20 or better level (60% of the MMC group vs 30% of the control group) and the 20/40 or better level (100% of the MMC group vs 83% of the control group) (Carones et al., 2002).

LASEK or Epi-LASEK, which is a variant of PRK, creates an "epithelial flap" that is then repositioned after laser ablation in an