Recent Advances in Cataract Surgeries

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Introduction

Cataract is an important cause of visual impairment worldwide. In Hong Kong, around 2300 cataract surgeries were done in the year 2005 in the Kowloon West Cluster of Hospital Authority Ophthalmic service and around 3000 patients with visually disabling cataract are on list awaiting cataract surgeries in the KW cluster of HA. Cataract represents a very large healthcare need.

The surgery itself can be done as either a day case operation or as in-patient operation and clinically, it is customised for different patients with different clinical needs. Having cataract is not itself an indication for surgery. In general, if people are still able to do all the things they enjoy with their vision then surgery is not needed. Therefore, cataract surgery may be indicated in patients who have a better visual acuity but a high visual demand whereas not indicated in another patient who may have a paradoxically poorer visual acuity but a much lower visual demand. The issue of informed consent is crucial.

The fundamental aim of cataract surgery, the removal of the opacified natural lens to improve vision, has remained the same for hundreds of years. Early cataract surgery between 1900 and 1940 was an invasive procedure involving a large limbal incision, cleavage of the zonules, and the removal of the lens and capsule together. The advent of extracapsular cataract extraction and phacoemulsification in the late 1960s led to improved surgical outcomes, quicker visual rehabilitation and better visual outcomes as a result of using smaller incisions and leaving the posterior capsule intact.

New technologies guarantee further changes. Recent advances include the surgical procedure itself by further reducing the size of the wound with bimanual microincisional cataract surgery (MICS) and advances in the intraocular lens (IOL) optical performances trying to overcome the issue of presbyopia (with multifocal or accommodative IOL) and further improve the optical quality of retinal image by customised correction of higher order aberrations with wavefront-corrected IOL.

Bimanual Microincisional Cataract Surgery (MICS)

Bimanual microincisional cataract surgery has recently become a procedure of interest among cataract surgeons. The procedure uses separate irrigation instruments and a sleeveless phaco tip to remove cataracts. Irrigation during phacoemulsification is provided through an irrigating chopper or manipulator instead of through the phacoemulsification handpiece. The surgery can be performed through incisions less than 1mm. The trend has been to minimise damage to the cornea by reducing the incision sizes, developing new power modulations to prevent injury to the corneal endothelium, and creating foldable lenses that can fit through small incisions. Bimanual phacoemulsification appears to be the next step in the development of cataract surgery. Clinical studies have been positive, emphasising the safety and efficacy of bimanual microincisional phacoemulsification on any of the currently available phaco systems and its potential as a minimally invasive cataract surgery. The main drawback remains the lack of intraocular lenses capable of being inserted through the small incisions. Early trials with rollable lenses appear to show promise that injectable IOL that can fit through incisions smaller than 2mm will soon be commercially available and will allow bimanual phacoemulsification to reach its full potential.

Wavefront-corrected IOL

In the phakic human eye (human eye with its natural lens in situ), two optical elements affect retinal image quality: the cornea and the crystalline lens. The aberrations of the cornea, specifically the anterior surface of the cornea, have been well studied. Individual corneas have unique continua of aberrations; yet, the average value of each aberration across the population is zero with the exception of spherical aberration, which on average is positive. Individual natural crystalline lenses also have unique continua of aberrations, and these aberrations can partially offset the aberrations of the cornea. Similar to the cornea, the average of each lenticular aberration across the population is zero with the exception of spherical aberration, which on average is negative. In the pseudophakic eye, the natural lens is replaced with an artificial lens. Hence, the average pseudophakic eye has a large amount of positive spherical aberration, as well as other higher-order aberrations associated with the cornea. Retinal image quality in pseudophakic eyes is limited by the wavefront aberrations of the cornea and the intraocular lens. The concept of replacing a cataract
with a wavefront-corrected IOL would theoretically balance the aberration of the cornea. The potential benefit of an IOL customised to correct the aberration of the cornea warrant the development of such an IOL (e.g. Tecnis Z9000, Acrysof IQ IOL, Bausch &Lomb AO). However, the predicted optical performance requires a very strict IOL centration. Minor tilting or decentration significantly reduces the optical performance of such an IOL. Furthermore, spherocylindrical refractive errors must be corrected to within a defocus equivalent error of 0.13D to reap most of the benefits of higher-order aberration correction. This is a difficult task, considering that the standard deviation of postoperative mean spherical refractive errors is roughly 0.5D to 0.75D. Finally, because the relation between higher-order aberrations and vision are not fully understood, the customised modifications with IOL had not been feasible yet.

Multifocal and Accommodative IOL

Accommodation in the youthful, phakic human eye is accomplished by contraction of the ciliary body and subsequently release in the resting tension of the zonular fibres by which the crystalline lens is suspended, resulting in increased lens curvature. Presbyopia is the age-related physiologic decrease of the amplitude of accommodation. Normally, a foldable IOL is implanted into the capsular bag in the posterior chamber of the eye during cataract surgery. The postoperative fibrosis and contraction of the capsular bag result in a firm fastening of the lens capsule to the IOL; thus, the IOL sits firmly in place postoperatively. Because the form of the IOL optic does not change during contraction of the ciliary muscle, a pseudophakic eye is unable to accommodate. Multifocal IOLs (diffractive or refractive) offer a certain independence from near glasses by spreading incoming light over several focal points. The simultaneous projection of several pictures on the retina, however, sometimes results in the perception of photic phenomenon and the frequently observed reduction in contrast sensitivity. The presence of halos around image borders and around typed letters for instance, could offset the advantages of spectacle independence. Therefore, multifocal IOL are still not used routinely in cataract surgery. It bears limited success especially in originally emmetropic eyes (eyes without refractive error) and patient satisfaction is highly variable.

Until now, the IOL optics was not sufficiently elastic to change their form according to the contraction of the ciliary muscle. The concept of pseudophakic accommodation can be achieved only by using special IOLs which are able to move the optic along the optical axis of the eye or change the optic design. Current designs of accommodative IOLs are supposed to work by the focus-shift principle to allow true pseudophakic accommodation. Studies that biometrically assessed optic shift found no or only low amplitudes of forward movement. The amount of forward movement, if present, was highly variable between patients.

The goal of cataract surgeons has long been to provide unaided, high-quality distance, intermediate, and near vision postoperatively. However, the perfect IOL which can overcome presbyopia is still awaited.

Cataract Surgery After Refractive Surgery

Increasing numbers of patients undergo corneal surgical procedures to decrease dependence on spectacles. Most of these procedures permanently and irreversibly alter corneal shape and its effective power. In 2002, an estimated 81800 LASIK procedures were performed in the United States. Patients who have undergone keratorefractive surgery are typically in their mid-30s. As this population ages, unavoidable development of visually significant cataracts will occur. Although performing modern cataract surgery in post-refractive surgery eyes is technically no more complicated than operating on virgin eyes, the calculation of IOL power for a desired refractive target can be challenging.

Conclusions

Cataract surgery is a rapidly advancing area, benefiting from various advances in technology and understanding of clinical optics and the visual performance of the human eyes. Bimanual microincisional cataract surgery, advances in multifocal or accommodative IOLs and wavefront-corrected IOL will contribute to most of the improvements in visual outcome after cataract surgery in the next few years.

References