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Aphakia—its optics and intraocular lens

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Abstract : Cataract is one of the main causes of blindness and poor vision. Lens opacities of varying severity occur in 60-90 percent of all people reaching the age of 60 years. Annually over 2.5 million cataract operations are performed throughout the World.

Modern microsurgical techniques make it possible to perform the operation with minimal ocular trauma and to exclude the risk of severe intra and extraocular post-operative complications.

However even when the operation is successful, at least 5,00,000-6,00,000 cataracts loose their professions because of spectacles or contact lens correction of an aphakic eye does not eliminate professional limitation in many areas of human activities because of limitation of optical properties of spectacles and contact lens. Implantation of an artificial lens first performed by the English Ophthalmologist Dr Harold Ridley in 1949 initiated an entirely new direction in cataract surgery improving aphakic correction to an almost ideal level and behave like a natural normal lens and this does not have the drawbacks of the other two methods of correction.

The optical advantage of the intraocular lens over the spectacles and contact lens will be discussed.

Keywords : Cataract, aphakia, spectacle, contact lens, intraocular lens, different position of intraocular lens.

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1. Introduction

The total dioptoric power of the normal phakic eye is (with lens inside the eye) +60 Dsph. ; of which lens contributes about 15 Dsph. to 18 Dsph. In old age the lens looses the transparency and becomes opaque leading to diminution of vision and we describe the condition as cataract (opacification of lens). When the cataractous lens is removed or extracted from the eye, the condition is called Aphakia.

2. The optics in aphakia and spectacles

An aphakic eye is usually hypermetropic ; in the absence of lens and other things being normal, parallel rays of light are brought to a focus 31 mm behind the cornea while the average antero-posterior of the eyeball diameter is only 23-24 mm. Hence the dioptric system must therefore be supplemented by a strong converging

lens (convex lens), if the eyes were originally emmetropic (no refractive error), of about +10 Dsph.

The optical conditions are completely changed, for the dioptric apparatus has been reduced to a single surface (cornea) bounding a medium of uniform refractive index (the aqueous and vitreous). The anterior principal focus is 23.22 mm in front of the cornea instead of 17.05 mm. Since the size of the image varies with this distance, the size of the image of the spectacle corrected aphakic eye (if the correcting lens was placed at this point) will therefore, be enlarged in the ratio of 23.22 to 17.05 or 1.36 to 1. The nearer the correcting lens is to eye, the smaller will be the difference ; nevertheless the result is that image in aphakic eye corrected by spectacles in their usual position is about 25% larger than the image in the phakic eye.

2.1. Disadvantages with spectacles correction in aphakia :

(i) The mechanism of the enlargement of the image is described already. The enlargement of the image introduces a false spatial orientation of familiar object which because of larger size are judged to be nearer than they actually are

(ii) Diplopia (double image) may result if there is good vision in other eye i.e. unoperated eye (leading to difference in size of retinal images in two eyes). There will be difficulty in fusion of images of two different sizes (aphakic being 25% larger than phakic) in brain leading to Diplopia.

(iii) Spherical aberration induced by strong convex lens is more awful ; the straight lines appear curved and linear world becomes converted into parabolas which change their shapes with each movement of the eye. Thus a rectilinear doorway which he approaches becomes curved inwards so as to leave a space only few inches wide at the middle, it is true that if he approaches it boldly, the opening widens to admit him, but this illusion is very disturbing.

(iv) The prismatic effect of deviation occurring at the periphery of a strong lens gives rise to ring of blindness arround the central visual field. When the eye move the circle of blindness moves also so that objects and persons suddenly appear and disappear. As the eye moves peripherally to fix an object of attention the roving ring scotoma (blindness) area moves in the opposite direction so that the patient suddenly does not see the person he is talking to, clumsily bumps into the furniture when he moves, stumbles on uneven ground or misses a step of the stairs with disastrous result. Only if he holds his eyes motionless and looks through optical centre of the lens moving his head only ; and not his eye, these objects assume their correct shape.

(v) As the glasses are thick and heavy they cause discomfort on the nose and often tends to slide forward. The eye of the patient appears magnified which besides effecting the patient cosmetically, jeopardises the job prospects as well.

3. Contact lens :

3.1. Its advantages

Contact lens may be used for correction of aphakia instead of spectacle correction. The advantages of contact lens are as follows :

(i) The magnification is about 6%. The difference is well tolerated and patient can maintain the binocular vision if the other eye has fairly good vision. There is no diplopia.

(ii) Depth perception is good with minimum distortion.

(iii) Peripheral field is normal.

(iv) The patient is not affected cosmetically.

3.2. The disadvantages of contact lens are—

(a) Usually patients are aged and find it difficult to handle and manage lenses ;

(b) High cylinders are difficult to correct.

4. Intraocular lens

The artificial lens is placed at the site of the original cataractous lens or close to that place, thereby correcting all menancing effects of spectacle lens and difficulties of handling contact lens. The quality of vision obtained by an intraocular lens closely resembles that of phakic eye. The first successful intraocular lens implant surgery was carried out by Sir Harold Ridley on 29th November, 1949 at St Thomas Hospital, London.

4.1. Criteria for use of intraocular lens

Indications of Intraocular Lens Implantation are unilateral cataract, traumatic cataract, patients with occupational special requirements e.g. pilots, surgeons, drivers. The implantation is absolutely contraindicated in patients with active iridocyclitis, proliferative diabetic retinopathy, congenital abnormalities of iris. The properties required for manufacturing intraocular lens are biological inerteness, chemical stability, absence of carcinogenic and allergic effects, reliable sterility and high optical clearance.

The lens is usually made of Perspex (Polymethylmethacrylate or P.M.M.A.). The disadvantages of P.M.M.A. are hardness, relative less optical resolution, chemical distruction at late stage. Now-a-days new lenses are being manufactured from Silicone (Polyorganosiloxane). These lenses are biologically inert, elastic, chemically stable, flexible, 200 times ligther than P.M.M.A. Its resolution is about 2 times higher than P.M.M.A. it is thermostable at +300°C.

Calculation of correct I.O.L. power is very important as otherwise the benefits of implant like lower postoperative correction, binocular vision etc. are lost.

4.2. There are three methods of calculation of power

(i) Clinical evaluation : The I.O.L. power can be calculated by a simple formula which required the patients refractive error at the age around 30 years (R) i.e. before the aging process of lens starts. I.O.L. power = + 19 Dsph. + (refractive error R × 1.25).

(ii) The I.O.L. power may be calculated on the basis of axial length (in mm) of eyeball by 'A' Scan Ultrasound and the corneal curvature (in dioptres) by Keratometry. This data is fed into the computer to obtain the required I.O.L. power.

(iii) The refractive state of the eye is measured after the removal of the lens (at the time of surgery) and suitable intraocular lens is placed inside the eyeball. The intraocular lens can be placed or fixated at three places. Iris fixated lenses are uniplanar with slits at two ends to fix at the iris. Anterior chamber lenses are of universal size due to compressible loops which adjust to the space in the anterior chamber i.e. in front of iris. At present the most preferred lens design is posterior chamber lens because the lens is placed in its natural position i.e. cataractous lens neucleus and cortex are removed and the lens is placed inside the capsular bag of the natural lens. If surgery is uneventful then there is hardly any complication postoperatively.

5. Conclusions

The principles and complications of implant surgery are usually explained to the patient. The risk factor is around 3% and visual improvement is achieved within a period of 2 to 3 weeks time. Patients should be informed that sometimes it may not be possible to insert lens which is in the interest of the patients.