Optical Power Regression Analysis

**Objective:-**

 To develop the testing specifications of IOLs made of 26% water content foldable material. This Project is mainly concerned with the determination of testing specifications (such as air power, insitu power and water power) to the foldable intraocular lens

**Introduction:-**

An intraocular lens (IOL) is a lens implanted in the eye used to treat cataracts. The most common type of IOL for cataract treatment are known as pseudophakic IOLs which work by replacing the crystalline les which has been clouded over by cataracts.



**History of an IOL :-**

 [Polymethylmethacrylate](http://en.wikipedia.org/wiki/Polymethylmethacrylate) (PMMA) was the first material to be used successfully in intraocular lenses. British ophthalmologist [Sir Harold Ridley](http://en.wikipedia.org/wiki/Harold_Ridley_%28ophthalmologist%29) observed that [Royal Air Force](http://en.wikipedia.org/wiki/Royal_Air_Force) pilots who sustained [eye injuries](http://en.wikipedia.org/wiki/Eye_injury) during [World War II](http://en.wikipedia.org/wiki/World_War_II) involving PMMA windshield material did not show any rejection or [foreign body](http://en.wikipedia.org/wiki/Foreign_body) reaction. Deducing that the transparent material was inert and useful for implantation in the eye, Ridley designed and implanted the first intraocular lens in a human eye.

**Basic terms:-**

 **Lens:-**

 A lens is a transparent material that passes the light with some slight changes in the parameters of light through refraction. This material is mainly made of glass with its surface is polished. It has the ability to shift the focus and to make the light fall on the desired location.

**Refractive index:-**

 The ratio between the velocity of light in air to the velocity of light in the medium. It is the characteristic of the lens that makes the light deviated from its path. It is because that the light is slowed down when there is refractive index. This behavior can be explained by the Fermat’s principle and Snell’s law.

**Dioptre:-**

The power the lens is measured in units of dioptre (m-1). Power is the focusing ability of the lens. Higher the power of the lens higher it shifts the focus of the light.

**Types of Lens:-**

 Lenses are classified by the curvature of the two optical surfaces. A lens is biconvex (or double convex, or just convex). If the both surface is convex. If the both surfaces have the same radius of curvature, the lens is equiconvex. A lens with two concave surfaces is biconcave. If one of the surfaces is flat, the lens is Plano-Convex or Plano-Concave depending on the curvature of the other surface. A lens with one concave and one convex is called convex-concave or meniscus. By convention, the convex lens’ parameters are measured positive and the concave lens parameters are measured negative.



**IOL :-**

 The most common type of IOL is pseudophakic IOL. These are implanted during cataract surgery, after the cloudy crystalline lens (otherwise known as cataract) has been removed. The pseudophakic IOL replaces the original crystalline lens, and provides the light focusing function originally undertaken by the crystalline lens.

IOL consists of an optic and two haptics.

 ****

**Optic:-** The central portion of the lens is called optic. The power of the lens is induced in this region. Its function is to focus the light rays on to the retina.

**Haptic:**

These are the “arms of the lens”. Their function is to keep the lens in its place. The lens has two curved haptics to be supported in eye bag.

**Types of IOL:-**

* Single vision
* Toric
* Accommodating
* Multifocal

Single vision intraocular lens is used to focus for a single distance.

Toric lens is a special form of a single vision cataract lens that has astigmatism.

A mulifocal lens gives focus to more than one of the important areas of vision.

**Factors affecting the quality of the lens:-**

The lens’ quality is affected by the defects arising in the lens. The five defects that arise in the lens are

* Spherical aberration
* Astigmatism
* Chromatic aberration
* Coma
* Defocus
* The spherical aberration occurs in spherical lens in which all rays does not converge to the same focus and the blurred image is formed.
* The chromatic aberration is the one in which different colors refract at different angles and the monochromatic image could not be obtained.
* Coma is the defect that rises in the lens due to imperfection in the optical design. It is defined as the variation in magnification over the entrance pupil.
* An Optical system with astigmatism is one where rays that propagate in two perpendicular planes have different focus.
* Defocus is due to longititudinal spherical aberration that occurs in the lens. The Paraxial rays (i.e. that makes very small angle with the optical axis) that converge the light to a different focus and the image obtained is not clear.

**Methods to measure power:-**

 Power can be measured using the following methods

* Power determination using measured dimensions
* Determination using back focal length
* Using measured magnification

**Power determination using measured dimensions:-**

The power of the lens is given by,

 **D= Df+Db-(C.T/nIOL)\*Df\*Db**

→Df and Db are powers of first and second optical surfaces respectively

→ C.T Centre thickness of the lens

**Df= (n***IOL***-n***med***)/rf**

**Db= (n*IOL*-n*med*)/rb**

→nmed and nIOL are the refractive indices of the medium and the IOL respectively

**→**rf and rb are the radius of curvature of front lens and back lens respectively

**C.T= Sag 1+ Edge.Thickness+Sag 2**

Where sag 1 and sag 2 are given by,

**SAG 1=r1**$-\sqrt{r1^{2}-(Optic dia/2)^{2}}$

**SAG 2= r2**$-\sqrt{r2^{2}-(Optic dia/2)^{2}}$

**Using EFL method:-**

EFL is the Effective focal length that is measured from the focal point to the principal plane.

BFL or Back focal length is measured from the back vertex of the lens to the back focal point.

FFL or Front focal length is measured from the front vertex to the front focal p ** **

**Measured magnification:-**

 Power of the lens is measured using the magnification of the lens. The lens bench instruments use this method for determination of power of the Intraocular lens.

**Instruments Required:-**

**Lens bench instrument:-**

 This instrument is used to measure optical power of the lens. Amongst the power the calculating methods, it uses the measured magnification method. The lens is kept on a tray and is focused and the power is calculated. The lens bench instrument is constructed so that it can be used to measure air and water power of the lens.

**Interferometer:-**

It is the instrument used to test the characteristics of the lens mainly the radius of curvature and to check the PV value required for the adjustment of lathe tool. The fringes formed due to alternative constructive and destructive interference is focused and the centre fringe is seen and the scale is zeroed. The radius is measured up to where the curvature becomes straight line. The PV is checked by the interferometer and the picture is displayed on the screen.

**Profile projector:**

The profile projector is used to measure the offset, Outer diameter, Optic diameter of the lens. In the projector the lens is focused. The projector is provided with the travelling microscope and the starting point is focused and the scale is zeroed and the parameters are measured using the digital Scale.

**Product Description:-**

The raw material used for making intraocular lens is called as 26% percentage of water content in the material with a thickness of 2.50mm and the outer diameter is 14.5mm having tolerance of ± 0.01mm. This lens is hydrophilic and is foldable one.

|  |  |  |
| --- | --- | --- |
| Process | Parameters checked | Value |
| First mounting | * Offset
 | * 0 to 0.05 mm

Tolerance |
| First lathe cut | * Optics diameter
* Outer diameter
* PV
* Radius of curvature
 | * 5.45±0.05 mm
* 14.2±0.005 mm
* ±0.1 µm
* 10.996 mm
 |
| Deblocking |  |  |
| Second mounting | * Outer diameter
 | * 14.2±0.005 mm
 |
| Second lathe cut | * Radius of curvature
* Power
* PV
 | * 10.996 mm
* ±0.25 tolerance
* ±0.1 µm tolerance
 |
| Deblocking | * Optic diameter
* Overall length
 | * 5.45±0.05 mm
* 10.71±0.05 mm
 |
| Milling | * Edge
 | * 0.28 mm
 |

**Methodology:-**

 For 26% water content material, the refractive index of dry iol is ---- and wet iol is -----.using this refractive index and power calculation method, find the radius of curvature from the power chart and then machined according to the radius.

**Power Checking:-**

 The lens is taken to the Quality control room and the Power is measured using Trioptic Instrument. The lens is mounted on the tray and is focused and the Instrument can now measure the power of the lens. The lens is hydrated to a time of 24 hours maintained in a bottle to check its Power in water medium. The conversion has to applied o that the water power estimated can be used to measure insitu (i.e) The Power in the real eye medium. The Lens bench measure the optical Power using measured magnification method if the power measured does not match with the calculated power from measured dimensions. The material is said to have error in refractive index.

The water power is checked and the insitu power is calculated by using the conversion factor.

**Methodology:**

 **Power Calculation and Measurements for 10 Dioptre**

 Niol dry = 1.518 Niol Insitu= 1.336

 Niol Wet =1.4602

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| S.No | Power Chart Radius | Measured Radius |  Pair  |  Pwater |  Pinsitu |
| Actual power | Measured Power | Actual Power | Measured Power | Actual Power | Measured Power |
|  1 | 22.04 | 22.06 | 46.69 | 46.725 | 10.24 | 10.431 | 10.01 | 10.186 |
|  2 | 22.04 | 22.05 | 46.69 | 46.813 | 10.25 | 10.3703 | 10.00 | 10.1273 |
|  3 | 22.04 | 22.04 | 46.69 | 46.781 | 10.26 | 10.4454 | 10.01 | 10.2006 |

The blank is to be machined to a power of 10D. Hence the power chart is referred and the corresponding radius of curvature is found and the lens is machined with that curvature. And the lens is taken to check the power. The power attained was not expected value hence the power dependence is on the refractive index of the IOL. The refractive index of the IOL is changed and the radius of curvature corresponding to the expected power is found and lens is remachined.

 niol dry = 1.66275 nInsitu= 1.336

 niol Wet =1.4618

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| S.No | Power Chart Radius | Measured Radius |  Pair  |  Pwater |  Pinsitu |
| Actual power | Measured Power | Actual Power | Measured Power | Actual Power | Measured Power |
|  1 | 22.323 | 22.318 | 46.69 | 46.148 | 10.24 | 10.237 | 10.01 | 9.997 |
|  2 | 22.323 | 22.318 | 46.69 | 46.366 | 10.25 | 10.289 | 10.00 | 10.048 |
|  3 | 22.323 | 22.318 | 46.69 | 46.342 | 10.26 | 10.234 | 10.01 | 9.995 |

 The blank is to be machined to a power of 10D. Hence the power chart is referred and the corresponding radius of curvature (22.318) is found and the lens is machined with that curvature. And the lens is taken to check the power. The power attained was not expected (10.434) value hence the power dependence is on the refractive index of the IOL. The refractive index of the IOL is changed (1.418) and the radius of curvature corresponding to the expected power(10.234) is found and lens is remachined.

  **15 Power Calculation and Measurements**

 Niol dry = 1.518 Niol Insitu= 1.336

 Niol Wet =1.4602

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| S.No | Power Chart Radius | Measured Radius |  Pair  |  Pwater |  Pinsitu |
| Actual power | Measured Power | Actual Power | Measured Power | Actual Power | Measured Power |
|  1 | 14.679 | 14.675 | 69.687 | 69.784 | 15.202 | 15.5746 | 15.02 | 15.2096 |
|  2 | 14.679 | 14.672 | 69.687 | 69.907 | 15.189 | 15.5677 | 15.00 | 15.2028 |
|  3 | 14.679 | 14.670 | 69.687 | 69.802 | 15.223 | 15.5602 | 15.01 | 15.3038 |

 The blank is to be machined to a power of 15D. Hence the power chart is referred and the corresponding radius of curvature is found and the lens is machined with that curvature. And the lens is taken to check the power. The power attained was not expected value hence the power dependence is on the refractive index of the IOL. The refractive index of the IOL is changed and the radius of curvature corresponding to the expected power is found and lens is remachined.

 Niol dry = 1.66275 Niol Insitu= 1.336

 Niol Wet =1.4618

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| S.No | Power Chart Radius | Measured Radius |  Pair  |  Pwater |  Pinsitu |
| Actual power | Measured Power | Actual Power | Measured Power | Actual Power | Measured Power |
|  1 | 14.868 | 14.860 | 69.687 | 68.9655 | 15.202 | 15.343 | 15.02 | 14.984 |
|  2 | 14.868 | 14.864 | 69.687 | 68.6999 | 15.189 | 15.349 | 15.00 | 14.989 |
|  3 | 14.868 | 14.868 | 69.687 | 68.7800 | 15.223 | 15.354 | 15.01 | 14.966 |

 The blank is to be machined to a power of 15D. Hence the power chart is referred and the corresponding radius of curvature (14.860) is found and the lens is machined with that curvature. And the lens is taken to check the power. The power attained was not expected (15.343) value hence the power dependence is on the refractive index of the IOL. The refractive index of the IOL is changed (1.418) and the radius of curvature corresponding to the expected power(14.989) is found and lens is remachined.

 **20 Power Calculation and Measurements**

 Niol dry = 1.518 Niol Insitu= 1.336

 Niol Wet =1.4602

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| S.No | Power Chart Radius | Measured Radius |  Pair  |  Pwater |  Pinsitu |
| Actual power | Measured Power | Actual Power | Measured Power | Actual Power | Measured Power |
|  1 | 10.996 | 10.894 | 92.042 | 92.645 | 20.252 | 20.593 | 20.001 | 20.111 |
|  2 | 10.996 | 10.705 | 92.042 | 92.890 | 20.258 | 20.668 | 20.020 | 20.184 |
|  3 | 10.996 | 10.896 | 92.042 | 92.868 | 20.234 | 20.691 | 20.109 | 20.206 |

 The blank is to be machined to a power of 20D. Hence the power chart is referred and the corresponding radius of curvature is found and the lens is machined with that curvature. And the lens is taken to check the power. The power attained was not expected value hence the power dependence is on the refractive index of the IOL. The refractive index of the IOL is changed and the radius of curvature corresponding to the expected power is found and lens is remachined.

 Niol dry = 1.66275 Niol Insitu= 1.336

 Niol Wet =1.4618

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| S.No | Power Chart Radius | Measured Radius |  Pair  |  Pwater |  Pinsitu |
| Actual power | Measured Power | Actual Power | Measured Power | Actual Power | Measured Power |
|  1 | 11.137 | 11.130 | 91.842 | 91.189 | 20.252 | 20.402 | 20.001 | 19.926 |
|  2 | 11.137 | 11.126 | 91.842 | 91.860 | 20.258 | 20.322 | 20.020 | 19.846 |
|  3 | 11.137 | 11.128 | 91.842 | 91.872 | 20.234 | 20.458 | 20.109 | 19.978 |

 The blank is to be machined to a power of 20D. Hence the power chart is referred and the corresponding radius of curvature (11.130) is found and the lens is machined with that curvature. And the lens is taken to check the power. The power attained was not expected (20.322) value hence the power dependence is on the refractive index of the IOL. The refractive index of the IOL is changed (1.418) and the radius of curvature corresponding to the expected power(14.989) is found and lens is remachined…