Predictability for Proper Capsular Tension Ring Size and Intraocular Lens Size

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Predicting correct capsular tension ring size and intraocular lens size using measurements of lens diameter, corneal diameter, axial length and capsular bag diameters to determine anatomical relationships of post implantation capsular tension ring (CTR). The vertical and horizontal diameters of cornea and lens were measured in 62 human eyeballs supplied from the eye bank of the Catholic University. The relationship between corneal diameter and axial length was examined in 195 living human eyes. An extension of capsular bag diameter after implantation of CTR was measured in 19 pigs’ eyes purchased from a slaughter house. The correlation between the lens diameter and the capsular bag diameter after CTR implantation was analyzed using linear regression. The average diameters (mean of horizontal and vertical diameters) of cornea and lens in human eyeball of postmortems (average age: 69, ratio of male : female = 23:39) were 11.59±0.42 mm for horizontal diameter, 9.54±0.27 mm, for vertical diameter. The average corneal diameters and axial lengths in living human eyes (average age: 62, ration of male : female = 84 : 111) were 11.63±0.53 mm for the cornea diameter, 24.48±2.10 mm, for cornea axial length. There is a statistically significant correlation between corneal diameter and axial length (correlation coefficient=0.788; p<0.001) and corneal diameter and lens diameter (correlation coefficient=0.711; p<0.001). In pigs’ eyes, there is a relationship between lens diameter and capsular bag diameter after implantation of 11 mm CTR (correlation coefficient=0.684; p<0.001). In conclusion, axial length and corneal diameter may give surgeons a valuable clue to expected size of capsular bag and important parameters for selecting the correct sized CTR and IOL.

Key words: capsular tension ring, intraocular lens, capsular bag

INTRODUCTION

Posterior chamber intraocular lens (PC-IOL) have been preferred to anterior chamber IOL (AC-IOL) because of less inflammation, less chance of increased intraocular pressure, and less damage of intraocular structure. When PC-IOL is used, “in the bag fixation” of both haptics is preferred to sulcus fixation of both haptics or, one haptic in the bag and
the other haptic in the sulcus. In the bag fixation of PC-IOL is possible through intact continuous curvilinear capsulorhexis (CCC). CCC has many advantages, but it also has some complications, such as contraction of capsular opening, capsular bag distension, and development of post-procedural cataract.

Capsular tension ring has been developed to make the capsular bag space stable for zonular dialysis or lens subluxation and to decrease the incidence of post-procedural cataracts. CTR size and PC-IOL length are important for decreasing the capsular bag stress. However as capsular bag size can not be measured prior to the cataract operation parameters have been studied to calculate the size of pre-operative capsular bag. In this study we compared the diameter of cornea and lens, of cornea and axial length, and the real size of capsular bag before and after CTR implantation. This data can help the surgeon estimate capsular bag size and thereby select the correct sized CTR.

MATERIALS AND METHODS

One hundred ninety-five eyes, from 154 patients (male: 84 eyes from 67 patients, female: 111 eyes from 87 patients) with no significant ocular pathology were obtained. Axial length of the eyeball was measured with an A-scan ultrasonography. Horizontal and vertical diameters of cornea were measured with a slit lamp and a video monitor. The relationship between axial lengths and corneal diameters can then be evaluated.

Sixty-two eyes were obtained after death from 38 patients with no significant ocular pathology (male: 23 eyes from 15 postmortems, female: 39 eyes from 23 postmortems). The eyes were measured without prior preparation. Corneal diameters were measured first. Afterwards the cornea and iris were carefully removed then horizontal and vertical diameters of lens were measured using an operating microscope with a video monitor and an appropriate scale. These two sets of measurements were then evaluated.

Pigs eyes were used to measure the diameter of lens and empty capsular bag. The globes were cut into two halves at the equator; and the anterior half was fixed to a slide glass at the scleral edge with adhesive glue. A viscoelastic substance (sodium hyaluronate) was injected into the vitreous cavity to replace vitreous loss during preparation. The horizontal and vertical diameters of the lens were measured by turning the slide glasses over using an operating microscope with a video monitor. The cornea and iris were removed and the lens’s material, including the anterior capsule, was removed after a 6.0-mm CCC was made. An 11 mm capsular tension ring (CTR) was placed within the capsular bag after viscoelastics had been injected into the clean capsular bag. The CTR is an open polymethylmethacrylate ring manufactured by Lucid Korea. The diameter of capsular bag after CTR implantation was also measured using an operating microscope with a video monitor. The relationship between these two parameters was then evaluated.

From this data, the relationships between axial length, corneal diameter, lens diameter and capsular bag diameter were analyzed using linear regression.

RESULTS

In 195 living human eyes the average corneal diameters was 11.63±0.53 mm (mean±SD), and axial lengths was 24.48±2.10 mm. The ranges were 10.6-13.0 mm for the corneal diameters, 19.5-32.6 mm for axial lengths (Table 1). There is a significant relationship between corneal diameter and axial length (correlation coefficient=0.788; p<0.001) (Fig. 1).

In 62 eyes of postmortems, the average corneal diameter was 11.59±0.42 mm (mean±SD) and lens diameter was 9.54±0.27 mm. Average diameter is the mean of horizontal and vertical diameter. The ranges were 10.7-12.3 mm for the corneal diameter, 8.7-10.2 mm for lens diameter (Table 1). There is a significant relationship between corneal diameter and lens diameter (correlation coefficient=0.711; p<0.001) (Fig. 2).

In pigs’ eyes, after implantation of the 11 mm CTR, there is a relationship between lens diameter and capsular bag diameter, with a correlation coefficient=0.684; p<0.001 (Fig. 3). The average lens diameters were 9.48±0.34 mm and empty capsular bag diameters were 10.58±0.21 mm. Mean difference between the lens and empty capsular bag size after tension ring implantation was 1.09±0.25 mm,
ranging from 0.6mm to 1.6 mm (Table 1). The differences appeared to be related to the original lens size. Regression analysis showed significant negative correlation (correlation coefficient=-0.800; p<0.001); this means that the larger the original lens size, the less the increase in size after evacuation (Fig. 4).

**DISCUSSION**

Modern cataract surgery consists of two main procedures. One is extracapsular extraction which removes the cataractous lens nucleus and cortex, leaving the evacuated capsular bag. The other is IOL insertion into the capsular bag, for anatomical and functional restoration of the bag and visual rehabilitation. The IOL’s diameter must closely match that of the crystalline lens. The size of the lens in normal adult has been reported to average 9.6 mm in diameter.5

Mean horizontal and vertical diameters of the lenses were 9.54 mm. They ranged from 8.7mm to 10.2 mm and showed a relatively large individual variation. It may be logical to vary the size and configuration of an IOL with eyes of a significantly different lens size.

The axial length was directly proportional to the corneal size, and corneal size was directly proportional to lens size. The lens’s diameter increases with axial length. Using an A-scan ultrasonography...
the axial length can be easily measured. Although the exact lens size could not be measured in vivo, we can use the axial length rather than the lens diameter. Therefore size and configuration of the IOL must be selected according to axial length. Predictions for patients who have eyes with axial length in the range of about 22 to 27 mm will be correctly matched using the most frequently used IOL of 12.5 to 13.0 mm. For those with eyes larger than 27 mm (i.e. extremely hyperopia) or smaller than 22 mm (i.e. high myopia) will be correctly matched using smaller or larger sized IOL, in the range of 0.5-1.0 mm.

Postoperative capsular shrinkage, particularly asymmetrical shrinkage, may lead to IOL decentration, tilting, or closure of the capsular opening, which may significantly impair postoperative visual acuity. To prevent postoperative capsular shrinkage, some researchers attempted to design a loop-less IOL that would exactly match the capsular bag. However the larger size of the IOL requires a larger incision and may induce significant astigmatism. CTR offers the potential to solve this problem. Based on previous studies and our experience we found that the CTR maintains the circular contour of capsular bag. No IOL decentration was observed during short-term follow up.

The capsular bag collapses when the lens substance is removed and the anterior capsule lies in apposition to the posterior capsule. The CTR confines residual cortical material and cells to the equatorial region by sealing between the cut edge of the anterior capsule flap and the subjacent posterior capsule, thereby retarding cell migration towards the visual axis. In 1997, Kugelberg et al reported that regular sized PMMA and silicone IOLs reduced the
Table 1. Measurements of globe dimensions.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean±SD (mm)</th>
<th>Range(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial length (n=195)</td>
<td>24.48±2.10</td>
<td>19.5-32.6</td>
</tr>
<tr>
<td>Cornea*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>living (n=195)</td>
<td>11.63±0.53</td>
<td>10.6-13.0</td>
</tr>
<tr>
<td>postmortem (n=62)</td>
<td>10.59±0.42</td>
<td>10.7-12.3</td>
</tr>
<tr>
<td>Lens* (n=62)</td>
<td>9.54±0.27</td>
<td>8.7-10.2</td>
</tr>
<tr>
<td>Pig eyes (n=19)</td>
<td></td>
<td></td>
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<tr>
<td>Lens*-a</td>
<td>9.48±0.34</td>
<td>8.8-10.0</td>
</tr>
<tr>
<td>CBD† after CTR*†-b</td>
<td>10.58±0.21</td>
<td>10.2-11.0</td>
</tr>
<tr>
<td>Difference between a and b</td>
<td>1.09±0.25</td>
<td>0.6-1.6</td>
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*: Mean of horizontal and vertical diameters, †: capsular bag diameter, ‡: capsular tension ring

amount of post-procedural-cataract in the growing rabbit eyes compared with that in aphakic eyes. This was due to the increased tension on the capsular bag by the CTR, and it probably also provided a mechanical obstacle to the lens epithelial cell proliferation. This effect was enough to reduce the amount of post-procedural-cataract.7

In our study, we planned to determine the correct size of the CTR. We used 19 pigs’ eyes with an 11 mm CTR. There was an increase of 1.09±0.25 mm in the capsular bag size after implantation of CTR. Although we did not measure the empty capsular bag size before capsular tension ring implantation, it is assumed that capsular bag size increases after tension ring implantation. There was a relationship between lens diameter and capsular bag diameter after implantation of the 11 mm CTR, whereas the increase in bag size showed a negative correlation. This negative correlation may be due to having used the same sized CTR without regard to lens size. If a larger CTR were implanted into a larger capsular bag, then there would be no reduction in the increase of the bag size. That means that the patient’s ocular dimensions should be considered when choosing the size of the capsular tension ring. Prediction of CTR size may be as possible as it is in predicting the IOL size.

In conclusion, when choosing the optimal IOL or capsular tension ring size and configuration, it is important to remember that some eyes have a large crystalline lens, especially eyes of those with a long axial length, and others with a short axial length, have smaller lens.

REFERENCES