Corneal Hydration Intra-operatively During Phacoemulsification

Abhay R. Vasavada, MS, FRCS; Sheena A. Dholakia, DO

Purpose: To evaluate incidence and risk factors for corneal hydration intra-operatively during phacoemulsification (CHIP).

Methods and Materials: This was a randomised, clinical trial, where 240 eyes of 240 patients with senile cataracts undergoing phacoemulsification were prospectively randomised to receive one of three possible types of incision architecture – single, two or three planes. Viscoelastic injection through paracentesis, before instruments were withdrawn from the main incision, was randomly done. Incision length was grouped into 1.5, 2 and 2.5 mm. CHIP was graded as nil, mild, moderate or severe: nil - no visible CHIP, mild-CHIP involving pillars of the incision, moderate - CHIP involving pillars and lateral extension, severe - extension of CHIP in front into the clear cornea. Moderate and severe categories were combined as ‘significant’ CHIP. Statistical analysis was done by logistic regression.

Results: The incidence of significant CHIP was 17.9 % (43 eyes out of 240). Five out of 80 eyes (6.25%) single plane, 8 out of 80 (10%) two plane and 30 out of 80 (37.5%) three- plane incisions developed significant CHIP (p = 0.005). Fifteen out of 120 (12.5%) with and 28 out of 120 (23.3%) without injection of viscoelastic developed significant CHIP (p = 0.044). Eighteen out of 43 (42.8%) and 25 out of 43(58.1%) with incision lengths 2 and 2.5 mm developed significant CHIP respectively (p<0.001).

Conclusions: The incidence of significant CHIP was 17.9 %. Three-plane incisions, not injecting viscoelastic prior to retraction of instruments and incision length 2 mm or more are risk factors for significant CHIP.

Key words: incision, phacoemulsification, viscoelastic substance

with a single functioning eye were excluded. Patients with co-existing corneal pathology (such as old healed viral keratitis, eyes with vascularised scar, corneal dystrophy and degeneration), other ocular diseases (such as uveitis, glaucoma and pseudoexfoliation), history of intraocular surgery (such as anti-glaucoma surgery, retinal detachment surgery and refractive corneal surgery) and small pupils were also excluded.

The recruited patients were seen preoperatively by a single observer (SAD), through the slit lamp biomicroscope (SL-120 Carl Zeiss, Germany) after mydriasis, using Tropicamide (Tropicacyl 1%, Sunways (I) P. Ltd., India) eye drops. The density of cataract was graded according to the classification of Emery and Little\(^6\) using system of grades 1–5. The oblique slit beam width and height were fixed at 0.3 and 0.9 mm, respectively, looking at 45\(^\circ\) and fixing illumination at intermediate level. Fixation light was set so that the slit-lamp beam was on the temporal side of right eye and nasal side of left eye in such a manner that it bisected the lens from 12 to 6 o’clock and focused near the centre of the lens. For statistical analysis, eyes with only cortical and/or posterior sub-capsular cataract were considered as grade 0. Preoperatively, noncontact specular microscopy using the Konan SP 8000 noncon ROBO specular microscope (Konan Medical Inc., Japan) was performed.

The surgical procedures were performed by a single experienced surgeon (ARV), by a standardised technique. The two factors randomised were architecture of the incision and viscoelastic injection through paracentesis before instruments were withdrawn from the main incision. The envelope system was used for randomisation of eyes, described in the flowchart [Figure 1]. In this system, prior to commencing the study sequenced and sealed envelopes were prepared containing one of the optional surgical procedures. A nurse in the operating room would open an envelope just before the surgery and announce the procedure to the surgeon.

Three types of temporal clear corneal incisions were constructed depending upon the randomisation. Single-plane incision was constructed by direct entry with a 3.0 mm angled slit knife (SatinSlit\textsuperscript{TM} Alcon surgical). Two-plane incisions was constructed with 15 No. D knife on a Bard Parker handle with a groove of approximately half thickness, followed by the entry with a 3.0 mm angled slit knife (SatinSlit Alcon surgical). Three-plane incisions had a groove which was made as described above followed by blunt dissection with an angled bevel up crescent knife (Satin Crescent\textsuperscript{TM} Alcon surgical) after which entry was performed with a 3.00 mm angled slit knife (SatinSlit Alcon surgical) [Figure 2A–C].

The anterior chamber was filled with 2% Hydroxy propyl methyl cellulose (Viscomet, Milmet Inc., India). Subsequently, continuous curvilinear capsulorhexis (CCC\textsuperscript{7} was performed with 26 G bent cystitome. The paracentesis was made with a 15\(^\circ\) Ophthalmic knife (Alcon surgical). Hydrodissection\textsuperscript{8} was performed with a 27 G cannula mounted on a 2 cc syringe. The nucleus was rotated with an iris spatula through the paracentesis.

Phacoemulsification was performed with an Alcon\textsuperscript{®} Legacy 20 000 phacoemulsifier. Central sculpting was done with 25\(^\circ\) bent kelman microtip with a 45\(^\circ\) bevel. Parameters were adjusted appropriate to the grade of cataract. For firm cataracts, above grade-1, we used our previously published technique ‘step by step, chop \textit{in situ} and lateral separation\textsuperscript{9} and subsequently removed it by the chop, chop and stuff technique.\textsuperscript{10} For soft cataracts, we performed nucleotomy and then aspirated the lens substance using the Alcon Legacy 20000\textsuperscript{TM} phacoemulsifier.

The cortex was aspirated with a single port Irrigation/Aspiration (0.3 mm diameter) cannula. The difficulty in

![Figure 1: Flow chart](image1)

![Figure 2: A Depicts graphic representation of single-plane incision in profile. B Depicts graphic representation of two-plane incisions in profile. C Depicts graphic representation of three-plane incisions in profile](image2)
removing sub-incisional cortex and the consequent distortion of the incision was subjectively graded by the surgeon and categorised into distortion of incision [Figure 3] and no distortion of incision.

Viscoelastic injection through paracentesis before instruments were withdrawn from the main incision was randomly assigned [Figure 4]. Subsequently an Alcon Acrysof® SA60AT was implanted in the capsular bag. Residual Viscomet® was removed from the anterior chamber and from behind the IOL. Vancomycin (0.1 mg/1 ml) was injected intra-camerally.

The length of the incision (between external and internal lips) was grouped into three as 1.5, 2 and 2.5 mm. The incisions
were constructed by presetting the mark with a calipers. Total surgical clock time in minutes was noted.

Primary observations related to CHIP were recorded as nil – no visible CHIP; mild – CHIP involving only pillars of the incision; moderate – CHIP involving pillars and/or lateral extension; severe – extension of CHIP into the clear cornea [Figure 5A–C]. These observations were made during the sculpting, division, fragment-removal and irrigation-aspiration stages [Figure 6A–C] of the surgery by a single observer (SAD). Secondary observations of anterior chamber depth, surgical clock time and endothelial count were recorded by a single observer (SAD).

To determine the regression of CHIP, five patients each with mild, moderate and severe CHIP were followed-up every 8 h till CHIP disappeared.

Logistic regression models using SPSS software were applied to estimate the odds ratio of occurrence of CHIP. Test of difference of mean was applied to determine association of endothelial cell count and CHIP and surgical time and CHIP.

For the purpose of statistical analysis and clinical interpretation, CHIP was divided into nil and mild CHIP as one group and moderate and severe CHIP as the second group. Moderate and severe CHIP was considered to be ‘significant’ CHIP.

Since endothelial count is a running number; it was divided into less than or equal to median and more than median. Grade of cataract was divided into less than grade 3 and equal to or more than grade 3. Length of the incision was classified as 1.5, 2 or 2.5 mm. Total surgical clock time was classified as <20, 20–30 and >30 min.

**Results**

None of the eyes subjected to randomisation were excluded due to intra-operative complications.

The mean age of 128 men was 61.7 years (range 42–71, median 64 years) and of the 112 women was 60.5 years (range 44–70 years, median 62 years).

The incidence of significant CHIP was 17.9 % (43 eyes out of 240).

Mild, moderate and severe CHIP occurred in 110 out of 240 (45.8%), 37 out of 240(15.4%) and 6 out of 240 (2.5%), eyes respectively. Mild and moderate CHIP disappeared within 8 and 32 h, respectively, Severe CHIP disappeared by 48 hours in 3 eyes and 56 hours in 2 eyes.

Flow chart describes randomisation of surgical intervention. The stage of surgery at which CHIP developed is shown in [Table 1]. Logistic regression analysis is described in [Table 2]. Test of difference of mean to describe correlation of endothelial cell count and CHIP and surgical time and CHIP is described in [Table 3].

### Table 1: Stage of procedure at which significant CHIP developed

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sculpting</td>
<td>6 (14.0%)</td>
</tr>
<tr>
<td>Chopping</td>
<td>2 (4.6%)</td>
</tr>
<tr>
<td>Fragment removal</td>
<td>29 (67.4%)</td>
</tr>
<tr>
<td>Irrigation-aspiration</td>
<td>6 (14.0%)</td>
</tr>
<tr>
<td>Total</td>
<td>43 (100%)</td>
</tr>
</tbody>
</table>

**Discussion**

The entity of corneal hydration occurring intra-operatively has been recognised by surgeons, but as far as we are aware, the incidence and risk factors have not been reported in the literature. We had observed that CHIP occurs to a variable degree during phacoemulsification. Therefore, on the basis of the morphological pattern, we graded it as mild, moderate or severe. Although, incidence of mild CHIP was high, it does not hamper the surgeons’ visibility as it is restricted to the pillars of the incision. On the other hand, moderate and severe CHIP can obscure visibility and hamper the phacoemulsification procedure.

Hindrance in the surgeons’ visibility can lead to adverse consequences such as posterior capsule rupture and vitreous...
loss. Because of its clinical relevance, we have considered moderate and severe CHIP to be ‘significant’. Serious complications did not occur in the present study partly due to the extensive experience of the surgeon in performing the phacoemulsification procedure.

This phenomenon is transient and even in the most severe cases regression occurred by 48-56 hours. Occasionally, patients noticed CHIP when it was significant and these few patients needed reassurance regarding this transient phenomenon.

Of the incision architecture related factors, we believe that blunt dissection with a crescent blade produces pockets in which fluid collects. Hence the incidence of CHIP was highest in three-plane incisions. Lesser dissection on the sides by the crescent blade might reduce CHIP.

Viscoelastic placement before instruments were withdrawn from the main incision has several advantages. Injecting viscoelastic through the paracentesis has been recommended by Osher and Cionni to prevent forward bulge of anterior vitreous and posterior capsule, thus preventing posterior capsule rupture and/or anterior vitreous prolapse.5

Also, viscoelastic placement eliminates the need to irrigate while going in and out of the eye. Another indication of this technique is to prevent internal entry distortion. We believe that internal entry distortion may be a factor, which may lead to CHIP. When an instrument is withdrawn from the main incision, there is a momentary fish mouthing of the internal entry. Injecting viscoelastic prevents this phenomenon by maintaining the contours of the globe and creating a pressurised environment around the internal entry. The internal entry distortion classically occurs during sub-incisional manoeuvres such as cortex removal. Bimanual irrigation aspiration technique11 is preferable when cortex removal is difficult. In the present study, bimanual irrigation/aspiration was not performed as the surgical technique was standardised.

It is interesting to note that ‘significant’ CHIP developed mainly during the stages of fragment removal and irrigation-aspiration. Once the surgeon recognises CHIP in the early stages, injecting viscoelastic substance through the paracentesis may prevent further progression.

According to I. Howard Fine (personal communication), an increase in the surgical time promotes CHIP. The results of the present study support this view. We presume that increase in surgical time can be due to a combination of several factors of which could be grade of cataract, difficulty in removing sub-incisional cortex and number of instruments introduced and removed.

Incision length was varied as we believed that longer incision may lead to CHIP. There is greater distortion of the internal entry in longer incisions and more corneal stroma comes in contact with the irrigating fluid.

The corneal endothelial pump mechanism is responsible for the deturgescence of fluid from the corneal stroma.12 According to I. Howard Fine (written communication), corneal endothelial diseases can lead to intra-operative stromal hydration. However, since the process of CHIP is so transient, the endothelial pump mechanism may not play a significant role. It is possible that regression may occur later in eyes with lower endothelial count or with greater endothelial cell loss. However, we did not examine patients for this phenomenon. Difficulty in removing sub-incisional cortex was subjectively evaluated by the surgeon. The lack of objective assessment can be a source of observer bias.

Several other factors such as energy used during phacoemulsification and amount of irrigation fluid may contribute to CHIP. Similarly, although hydroxy propyl methyl cellulose was the viscoelastic used in the present study, other viscoelastics may influence the occurrence of CHIP differently and may be a subject for further research.

This randomised, controlled trial thus concludes that three-plane incisions, not injecting viscoelastic through paracentesis before instruments were withdrawn from the main incision, sub-incisional cortex removal difficulty, tunnel length 2 mm or longer and prolonged surgical time are risk factors of CHIP. Several of the factors that contribute to CHIP including plane of incision and incision length are modifiable. Identifying this phenomenon early in the genesis can help the surgeon take such appropriate measures as viscoelastic injection through paracentesis before instruments were withdrawn from the main incision, reducing the surgical clock time and other manipulations that could decrease the incidence of CHIP.

References