Review of Continuous Circular Capsulorhexis Technique "New Technology for Better Sizing and Centration"

Abstract

The cataract surgery has been modified over the time and the creation of a centered and precise capsulotomy can be challenging for surgeons in training. The term continuous circular capsulorhexis (CCC) described in 1987 is the actual method used by cataract surgeons. The efficacy of this technique depends on its centration, location, and size. It has been reported that the optimum CCC should be small enough to overlap 360 degrees of the IOL optic periphery to reduce posterior capsule opacification. Many devices have been created to improve the accuracy of CCC. Corneal and anterior capsular markers as well as substances to stain the anterior capsule (trypan blue) are the most used instruments while performing CCC. Different Image Guided Systems (Verion and Callisto Eye System) developed in the last years help surgeons by projecting a circular template of determined size on the anterior capsule intraoperatively. Laser assisted capsulotomy (LenSx) has been shown to be better centered than manual capsulorhexis with highly predictable diameters. Several factors when deciding which device to use must be taken into account: the availability of equipment, there producibility of the technique, the surgeon's experience and the cost of the instruments. Thus, devices that help surgeons to increase accuracy are the best alternative for better sizing and centration of CCC, resulting in fewer complications and better postoperative prognosis for the patients.

Keywords: Capsulorhexis; Capsulotomy; Anterior capsule

Mini Review

Volume 3 Issue 1 - 2015

Villalobos-Ojeda JC[1]* and Gabriel Lazcano-Gomez[2]

[1]*Anterior Segment Department, Asociacion para Evitar la Ceguera en Mexico, Mexico*
[2]*Glaucoma Department, Asociación para Evitar la Ceguera en Mexico, Mexico*

***Corresponding author:** Gabriel Lazcano-Gomez, Glaucoma Department, Asociación para Evitar la Ceguera en Mexico, Vicente Garcia Torres #46, San Lucas Coyoacan, Mexico City, Mexico, ZC: 04030, Tel: (52-1) 55 1084 14 00; Email: gabozidane12@hotmail.com

Received: September 27, 2015 | **Published:** October 19, 2015

Abbreviations: CCC: Continuous Circular Capsulorhexis; IOL: Intraocular Lens; PCO: Posterior Capsule Opacification; IGS: Image Guided Systems; SEM: Scanning Electron Microscopy; ICG: Indocyanine Green; FS: Fluorescein Sodium; BSS: Balanced Salt Solution

Introduction

The cataract surgery has been modified over the time; surgeons have taken advantage of technological devices to perform more precisely maneuvers in order to improve postoperative results. Undoubtedly, the creation of a centered and precise capsulotomy can be challenging for surgeons in training [1], further that there is no consensus about the best way to perform an ideal capsulorhexis. It is important to know about the history and new technologies to make an ideal capsulorhexis for the actual cataract surgery. This review aims to describe the different technology that is available for cataract surgeons.

History

The creation of the technique was reported since the 80´s in different parts of the world at the same time. In North America, Howard Gimbel completed curvilinear capsular tear back in 1983 while watching Dr. James Gills using a combination of scissors cuts and tears to make his capsular openings. He started to tear the capsule continuously around the 12 o'clock area and then around the whole anterior capsule, and called it continuous tear capsulotomy. In Europe Thomas Neuhann, developed a smooth, circular capsular opening and named this technique capsulorhexis, which appropriately uses the Greek suffix rhexis meaning "to tear." He presented the technique to the ophthalmology society in Germany in 1985. In Asia Kimiya Shimizu, developed a method by opening the capsule in a smooth, round fashion in 1986. He was unaware of the work of Gimbel and Neuhan and called this technique as circular capsulectomy and reported it for the first time at the Japanese ophthalmological surgeons meeting in January 1987 [2,3].

They proposed to give a common and complete descriptive name to his technique coined from the three original names; continuous tear capsulotomy by Gimbel, capsulorhexis by Neuhann, and circular capsulectomy by Shimizu. The name continuous circular capsulorhexis (CCC) was the most accurately descriptive name and coincidentally, used one word from each of the previous names [3]. The term capsulorhexis, meaning "to tear the capsule, more appropriately describes the technique than does the word capsulotomy, which means "to cut the capsule," or capsulectomy, which means "to cut out the capsule."

Advantages

The smooth and continuous tear of this circular opening meets the demands of advanced cataract surgery and intraocular lens (IOL) implantation [4-7]. The circular opening does not leave V-shaped tears, which have a tendency to extend to the capsular equator or even into the posterior capsule under minimal mechanical stress, it allows safe hydro dissection of the nucleus from its cortical attachments with minimal risk of a tear, facilitates IOL implantation and the visible rim makes it possible to verify the placement of IOL haptics within the bag.

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In cases in which posterior capsular defects do not allow bag placement of IOL, the preserved diaphragm quality of the peripheral anterior capsular rim additionally enables the secure placement of sulcus IOLs. The efficacy of the CCC depends on its centration, location, and size. It has been reported that the optimum CCC should be small enough to overlap 360 degrees of the IOL optic periphery to reduce posterior capsule opacification (PCO). A bigger CCC has been associated with greater opacification and worse visual acuity than smaller capsulorhexis. In contrast, when the CCC is too small, anterior capsule phimosis, decreased visualization of the retina and decreased effectiveness in the properties of a spherical IOLs can occur [8,9]. The success and diameter of the CCC depend on the surgeon's ability and experience. In complicated cases or when surgery is performed by an inexperienced surgeon, the risk for intraoperative complications increases because of an unsuccessful CCC.

Actual Technique

Many different methods has been described to perform CCC [10]; in general the technique starts after filling the anterior chamber with viscoelastic and puncture of the anterior capsule using a cystotome or a 23 gauge sharp needle and continue the tear in a circular fashion with a forceps clockwise or counterclockwise all the way around to the starting location [Figure 1A & 1B].

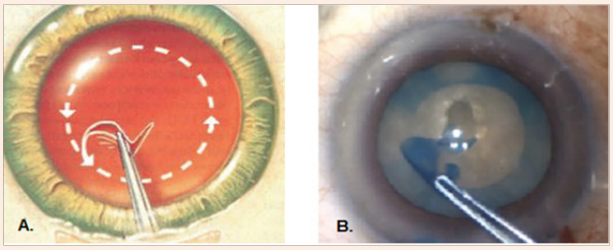

Figure 1A: Schematic representation of CCC.
Figure 1B: *In vivo* CCC with trypan blue.

Capsular staining

The introduction of capsular dyes has provided a great advantage in performing the capsulorhexis, improving visibility of the anterior capsular edge, resulting in a more precise capsulorhexis with a less probability of anterior capsular extension. Staining agents that have been used for cataract surgery included trypan blue 0.1%, indocyanine green (ICG) 0.5%, fluorescein sodium (FS) 2% [11], gentian violet 0.001% [12] and autologous blood [13]. Trypan blue 0.1% is the most commonly used dye for staining the anterior capsule as it creates intense and persistent staining provides good visualization and can be easily washed off with balanced salt solution (BSS) [14]. Many studies have reported the benefits of trypan blue in the absence of red reflex like white or hyper mature cataracts [15] and for surgeons in training [16].

New methods

Both, the Industry and surgeons are creating instruments and devices all the time to improve the accuracy of CCC. There are different types of markers: the Wallace circular corneal marker 6, that makes a 6.0 mm diameter circle mark on the cornea surface; this marker it's not very useful because of the corneal curvature and magnification and because the image on the anterior capsule differs from the original mark size and location. To solve this problem there are semicircle markers with a internal diameter of 5.5 mm that can make a semicircular mark direct on the lens capsule [17,18]. Figure 2 Surgical devices designed to provide a visual guide on the anterior capsule have also been developed. The Raviv Capsulorhexis Caliper (Bausch + Lomb) has blunt, adjustable marking tips that indent the anterior capsule on two axes after they are inserted through the main cataract incision (Figure 3).

Figure 2: Semicircular markers with 5.5 mm internal diameter.

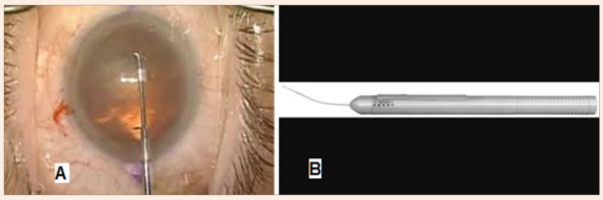

Figure 3: Raviv capsulorhexis marker.

The Morcher Ring Caliper (FCI Ophthalmics) is a sterile, temporary polymer ring of 0.25 mm with an internal diameter of 5.0 mm or 6.0 mm placed directly on top of the anterior capsule. After aligning the ring, the surgeon creates the capsulotomy while stay¬ing away from the inner margin of the ring (Figure 4). Verus Capsulorhexis Device (Mile High Ophtalmics) is a biocompatible silicone ring, with an outer diameter of 6.2 mm and an inner diameter of 5 mm. A micro patterned surface acts as a braking system once the device is placed on the capsule so that the ring maintains stability and limits side-to-side movement. A distinct angle to the inner edge of the ring enhances the ability to go through the anterior capsular flap along the inner diameter of the device for precise cre-ation of the capsulotomy (Figure 5). Different Image Guided Systems (IGS) like "Verion Image guided system" (Alcon) and "Callisto Eye Computed Assisted Cataract Surgery" (Carl Zeiss) have been developed to project a circular template of determined size on the anterior capsule intraoperatively (Figure 6A & 6B).

Femtosecond laser assisted capsulotomy

An increasing number of studies are reporting data on the safety and efficacy of femtosecond laser platforms to create anterior capsulotomy, the femtosecond laser capsulotomies have

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been shown to be better centered than manual capsulorhexis with highly predictable diameters [19,20]. (Figure 7) Many other studies have analyzed the lens capsulotomies using either optical or scanning probe microscopy techniques. High-resolution scanning electron microscopy (SEM) imaging has revealed Irregularities at the capsulotomy edges, which have not been observed Lensx [21,22]. (Figure 8A & 8B) Eye movements during surgery (that are in the range between 20 and 100µm) have been considered to contribute to increased capsulotomy edges' irregularities, by creating multiple, random cavitations that could compromise the integrity of the capsular edge and represent a point for a tear to initiate with adequate force during the capsulotomy pulling, hydro dissection, or nucleus manipulations [23].

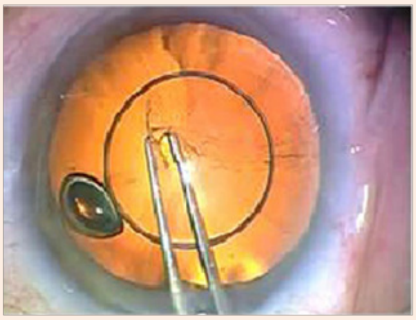

Figure 4: Morcher Ring Caliper (internal diameter of 5.0 or 6.0 mm).

Figure 5: Verus Capsulorhexis Device (inner diameter of 5 mm).

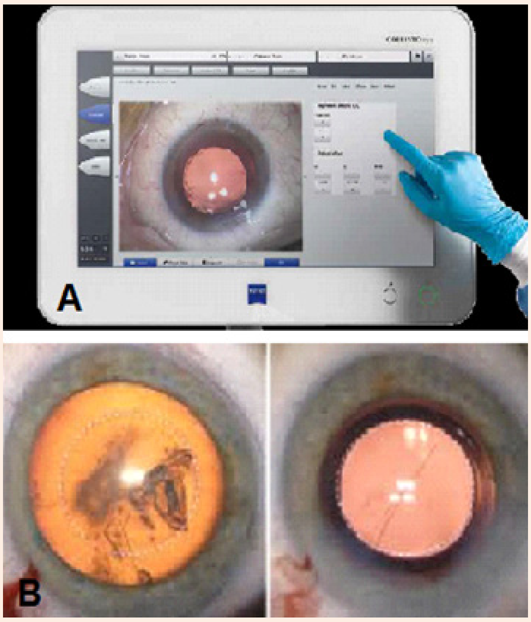

Figure 6A: Callisto Eye Computed Assisted Cataract Surgery.

Figure 6B: Anterior Capsulorhexis Assistant.

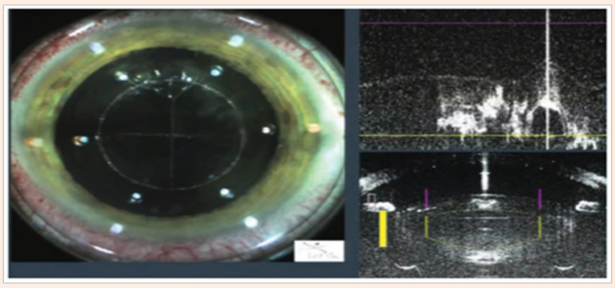

Figure 7: Image illustrating the real time anterior chamber during a four-quadrant lens chop and anterior capsulorhexis with the LenSx (Alcon) system.

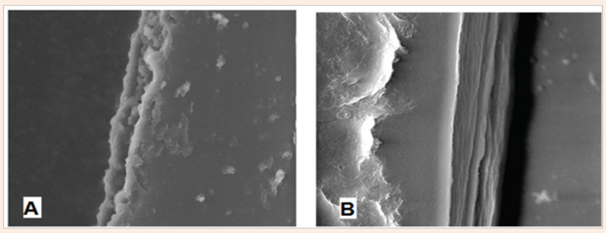

Figure 8A: Scanning electron microscopy femtosecond capsulorhexis.

Figure 8B: Scanning electron microscopy manual capsulorhexis.

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Conclusion

Until now, the accuracy of a CCC created using the free-hand method depended on the surgeon's ability and experience, and the CCC was not always reproduced the same way. All devices and instruments to facilitate the realization of the capsulorhexis are useful, however, several factors when deciding which device to use must be taken into account: the availability of equipment, there producibility of the technique, the surgeon's experience and the cost of the instruments. However, it is important to note that technology sometimes may not be necessary. In some patients with previous unhealthy corneal endothelium (diabetic patients, history of prior corneal transplant, corneal dystrophies, prior intraocular inflammation history or elderly patients) the use of Intracorneal rings or stains, could irreversibly damage the cornea and produce ocular inflammation so they should not be used routinely.

In developing countries, where it does not have the financial resources to acquire the equipment, the skill of the surgeon is the main instrument to achieve adequate capsulorhexis. We recommend inexperienced cataract surgeons watch as many videos of expert surgeons as possible in order to know the basic steps of the surgery, surgeon's advice and the way the experts could resolve any possible complication during the surgery. In our hospital, ophthalmologists in training practice with Cataract Surgery Simulators (Eyesi Cataract; Vrmagic Holding AG) until they achieve adequate skills to perform a real cataract surgery.

With proper intraoperative management, patients with manual CCC have excellent visual results. Cataract surgical techniques must be adapted to suit each patient. The modification of surgical techniques according to individual patient needs and associated ocular and systemic disorders offers a distinct challenge to the ophthalmic surgeon. Thus, devices that help surgeons to increase accuracy are the best alternative for better sizing and centration of CCC, resulting in fewer complications and better postoperative prognosis for the patients. However, "simplicity is the ultimate goal and golden rule of any surgery".

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