The Role Of The Specular Microscopy In Endothelial Cell Changes Before And After Phacoemulsification

Deza Yumardika[1], Gusbakti Rusip[1], Gede Pardianto[1]
[1]Universitas Prima Indonesia

ABSTRACT

Cataracts remain one of the leading treatable causes of blindness around the world. Phacoemulsification is the most frequently used technique for cataract extraction. The ultrasound (U/S) power needed for traditional or longitudinal phacoemulsification poses ongoing risks for endothelial cell loss and tissue damage. The examination of endothelial cells before phacoemulsification surgery is very important in determining the prognostic factors for visual acuity after cataract surgery. Specular microscopy is a non-invasive tool that is essential in ophthalmology, facilitating the evaluation of the corneal endothelium, a crucial aspect in eye health assessment and surgical planning. It provides detailed images that showcase the size, shape, density, and overall condition of the endothelial cells.

Keywords: specular microscopy, cornea, endothel, cataract, phacoemulsification

INTRODUCTION

Phacoemulsification was first proposed by Charles David Kelman in 1948, and the idea was approved in 1967. When Kelman first went to the dentist, he saw that ultrasonic energy was being used to remove teeth debris and enamel. He removed the lens at 40,000 rpm using a hollow 1 mm titanium needle (phaco tip) and ultrasonic power, following a similar principle.[1]

Additionally, phacoemulsification aspirates the cortex and nuclear fragments using an automated irrigation and aspiration device that is guided by a surgeon. At first, there was resistance to the procedure because of the significant risk of complications and the requirement to widen the incision in order to fit the polymethyl methacrylate intraocular lens (PMMA IOL). Many developments, including the introduction of foldable IOLs, continuous curvilinear capsulorhexis, ocular viscosurgical devices (OVDs), and better phaco machine quality and performance, contributed to the technique's rise in popularity in 1980.[2]

The ophthalmic surgeon uses two paracenteses and a 2.8 to 3.2 mm keratome to make a clean corneal incision during phacoemulsification. The anterior lens capsule is then stained, capsulorhexis of the appropriate size is carried out, and an ultrasonic phaco probe is placed through the primary wound to emulsify and aspirate the nucleus. A foldable IOL is then implanted after the remaining cortical matter has been extracted from the capsular bag. The patient may be released the same day after the operation, which is carried out under local or topical anesthesia or as an elective procedure. Uncomplicated cases typically have a perfect visual outcome on the first postoperative day, and as globe remodeling occurs, the vision gradually gets better until 4 to 6 weeks.[3]

When the lens develops cataracts and reduces visual acuity, phacoemulsification is recommended. Reduced near or distant visual acuity, colorful halos, photophobia, monocular diplopia, diminished contrast sensitivity, and white reflex in the pupillary area are some of the different signs.[4]

Posterior subcapsular cataract, nuclear cataract, cortical cataract, brown cataract, mature cataract, nuclear opalescence, traumatic cataract, posterior polar cataract, and subluxated cataract with capsular support devices are among the different forms of cataracts that necessitate cataract surgery. Additionally, several occupations, such as driving, flying, the military, and handling complicated machinery, require flawless visual acuity with minimally acceptable standards.[5]

The role of Specular microscopy in the examination of corneal endothelial cells

The corneal endothelium consists of a single layer of hexagonal-shaped cells, and evaluating the condition of this layer is crucial for eye health.[6] The endothelial cell layer is just one cell thick and is crucial for maintaining corneal dehydration and clarity. These cells serve as a barrier against fluid from the aqueous humor and help pump excess fluid from the stroma to prevent swelling of the cornea. Any dysfunction or reduction in cell count can lead to corneal edema and decreased visual acuity. Unlike other cells in the body, human corneal endothelial cells are post-mitotic, meaning they do not regenerate. This underscores the importance of monitoring their health and integrity to prevent and manage corneal diseases.[7]

Endothelial cell density decreases with age at an average rate of 0.6% per year, occurring in two phases: a rapid decline followed by a slower one. At birth, the endothelial cell density is around 6000 cells/mm, which gradually decreases to about 3500 cells/mm by the age of 5. By ages 15 to 20, it falls to approximately 3000 cells/mm, and by age 50, it reaches about 2500 cells/mm.[8]

Corneal endothelial cell damage can lead to corneal decompensation following phacoemulsification. Therefore, endothelial cell loss is a critical prognostic factor in determining the surgical outcomes of phacoemulsification. Identifying risk factors associated with corneal endothelial cell loss—including preoperative, intraoperative, and postoperative parameters—is essential for accurately assessing the prognosis after surgery.

The advancement of non-contact specular microscopy has enabled a safer and more efficient assessment of the corneal endothelium, enhancing patient comfort and practitioner convenience. During a specular microscopy examination, light is directed at the cornea and reflected off the inner endothelial layer, generating an image that can be analyzed to evaluate endothelial cell density (ECD), cell size (polymegathism), and cell shape (pleomorphism).ECD serves as a key indicator of endothelial health, with a lower count indicating a compromised cornea.[9]

Specular microscopy is vital before cataract surgery to determine if the endothelium can handle the extra stress of the procedure. This evaluation aids in predicting the risk of corneal decompensation after surgery, thereby informing both the surgical approach and postoperative care.[10]

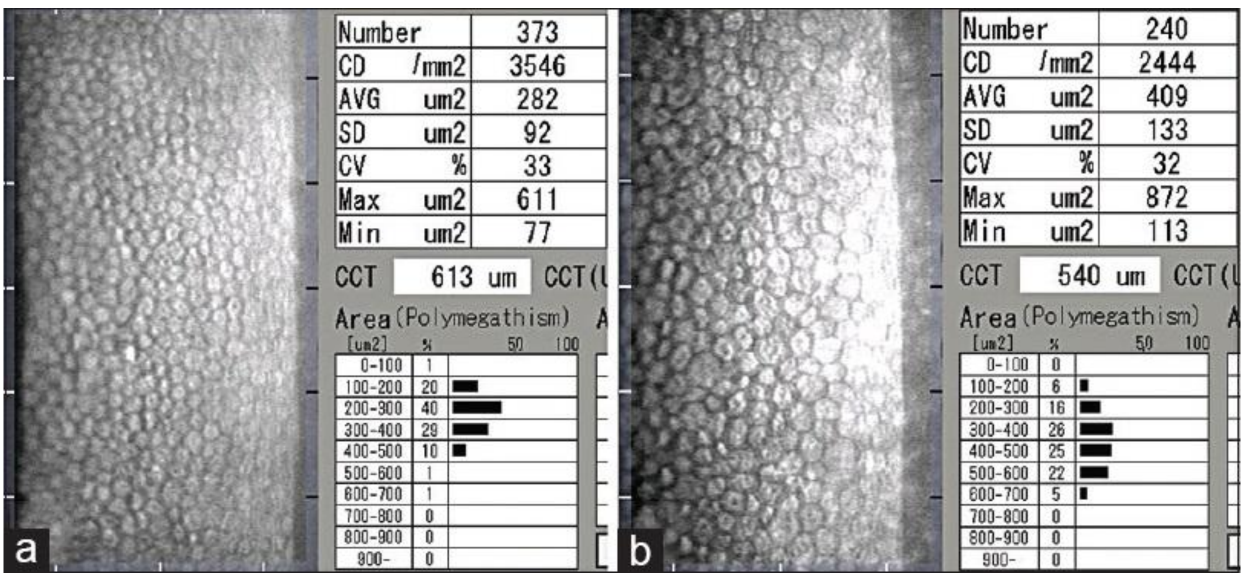

Figure 1. Representative specular microscopy images of the right eye of a 12-year-old (a) and a 40-year-old (b) male. Notice the difference in the mean cell area (282 versus 409 µm2) and the age-related decline in endothelial cell density[11]

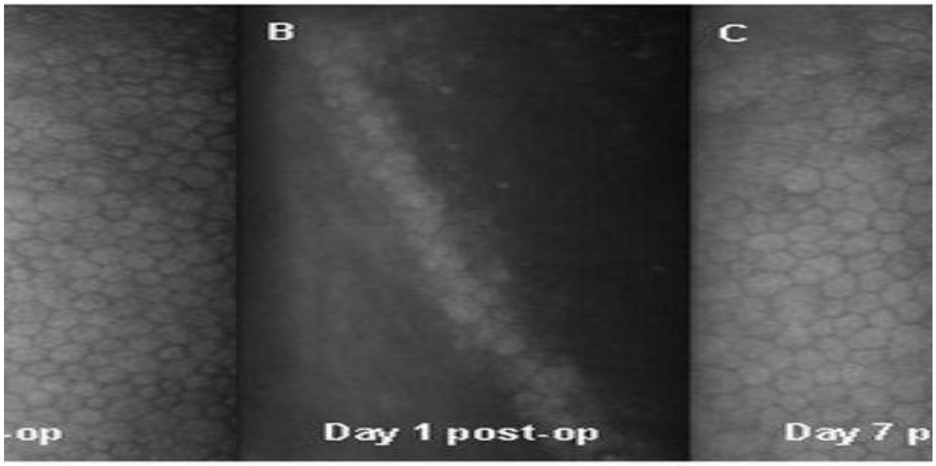

Figure 2. Representative specular microscopy images of endothelial cells before and after cataract surgery. (A) Prior to surgery, the endothelial cells were relatively uniform in size and shape. (B) Due to corneal edema on Day 1 after surgery. (C) The larger cells and decrease in cell density were still evident on Day 7 after surgery.[12]

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