The Changes of Retinal Nerve Fiber Layer (RNFL) in Cataracts undergoing Phacoemulsification using Spectral Domain Optical Coherence Tomography

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ABSTRACT

Retinal nerve fiber layer (RNFL) is one of the vital layers of the retina with regard to the incidence and subsequent treatment of glaucoma. The damage done by glaucoma specifically involves this layer. Optical coherence tomography (OCT) is widely used by ophthalmologists for diagnosing and following retinal diseases such as diabetic retinopathy (DR), and OCT measurement of RNFL thickness is valuable for glaucoma screening and detection of progression. Cataract affects the measurement of retinal nerve fiber layer thickness as measured on OCT; and cataract surgery enhances the ability of OCT to measure the changes in retinal layers. We need to pay attention about the effects of phacoemulsification on RNFL thickness and its consequences to preserve the eye delicate tissues and structures and assure its functions and the knowledge will be beneficial for patients' treatment in future.

Keywords: RNFL, OCT, SD-OCT, phacoemulsification, cataract

INTRODUCTION

Cataract surgery is one of the most consistently performed surgeries around the world. During cataract surgery, the opaque cataractous lens is replaced by an artificial, transparent intraocular lens.[1] Since its start two centuries back, the cataract surgery has gone through various stages of refinement. Intracapsular cataract extraction[2] was refined to extracapsular cataract extraction,[3] in which the lens capsule was preserved for the implantation of artificial intraocular lens. Currently, phacoemulsification is the surgery of choice for cataract due to its minimal per- and postoperative complications and an early visual recovery with better patient comfort.[4-6] Retinal nerve fiber layer is one of the vital layers of the retina with regard to the incidence and subsequent treatment of glaucoma. The

damage done by glaucoma specifically involves this layer.[7,8] OCT is a non-invasive medical diagnostic imaging technology that captures three dimensional micro-resolution images of retina.

Optical coherence tomography (OCT) in the field of ophthalmology is firstly and widely used by ophthalmologists for diagnosing and following retinal diseases such as diabetic retinopathy (DR), and OCT measurement of peripapillary nerve fiber layer (NFL) thickness is valuable for glaucoma screening and detection of progression.[9] It is based on the principle of optical reflectometry which involves the measurement of light back scattering through transparent or semi-transparent media such as biological tissues.[10] Various models of OCT are available, which measure the retinal nerve fiber layer thickness and there is agreement between them regarding measurement of retinal nerve fiber layer thickness.[11] Measurement of retinal nerve fiber layer thickness by OCT is affected by various factors such as age, gender, axial length, race and optic nerve head parameters, so these must be kept into account while making any decision regarding any treatment.[12,13] Literature suggests that ocular surgery, whether that of the anterior segment or of the posterior segment, does affect the retinal nerve fiber layer thickness.

A common clinical feature in glaucoma patients is progressive decrease in Retinal Nerve Fiber Layer (RNFL) thickness. Changes in RNFL thickness have been used not only for the diagnosis but for monitoring of disease progression as well. Among the various imaging modalities, OCT has gained lot of interest in the assessment of RNFL thickness due to its convenience, accuracy and minimal inter-observer variability.[14,15]

Existing literature indicates that phacoemulsification results in improvement of RNFL thickness and decrease in Intraocular Pressure (IOP). Jha et al. used spectral domain OCT for assessment of retinal changes following cataract surgery and reported that there was increase in mean RNFL thickness one week after the surgery.[16] Studies have also shown that there is reduction of IOP probably owing to widening of anterior chamber depth and increased drainage of aqueous humor.[17] However, literature either shows effect of cataract surgery on IOP and

RNFL thickness in patients with cataract alone or if they included glaucoma patients, the comparison between the glaucoma and non-glaucoma was not made. One research compared RNFL thickness between glaucomatous and non-glaucomatous eyes.[18] However, the available research evidence was limited and there was no such published research in the local population, which necessitated the conduction of present study. As RNFL thickness is important marker in the diagnosis, prognosis and risk stratification of patients with glaucoma, so there is need to study the effect of cataract surgery in patients with co-existing glaucoma and to compare the results with non-glaucomatous eyes.[19]

Phacoemulsification cataract surgery is typically performed under topical anesthesia using proparacaine drops applied to the ocular surface. The procedure is divided into four key stages:

(a) Corneal incision: The ideal incision should be small, astigmatically neutral, and free of sutures. It can be made through a scleral tunnel or in the clear corneal. The clear corneal incision, located in front of the limbal vascular arcade, is the most commonly preferred approach by ophthalmologists due to its self-sealing properties and compatibility with foldable intraocular lenses (IOLs). The standard incision size is about 2.8 mm, but options can go down to 2 mm or smaller, typically determined by the size of the phaco probe.

(b) Capsulorhexis: This step involves creating an opening in the crystalline lens capsule. Ultrasonic energy is delivered through a handheld probe with a titanium or steel tip, which vibrates and oscillates rapidly against the lens mass. The continuous circular capsulotomy (CCC) is the most widely used emulsification technique. This method allows for an intact capsular bag for IOL implantation and was introduced by Gimbel and Neuhann in the mid-1980s, offering several advantages.

(c) Phacosculpture: During this phase, the lens is fragmented (emulsified) using ultrasound and subsequently removed through the same instrument via aspiration. The most common technique involves initially breaking the lens into four quadrants, followed by separate aspiration of each quadrant. This process consists of four main steps, beginning with deep sculpting of the nucleus until a very thin posterior plate remains. Next, the nuclear rim and posterior plate are fractured using

lateral pressure with a probe and spatula. This step is repeated after rotating the core by 90 degrees to break off a wedge-shaped section for emulsification. The procedure concludes with systematic emulsification of each square section.

(d) IOL implantation: After phacoemulsification, the posterior capsule is preserved to support the IOL, which replaces the cloudy lens. The acrylic lens is the most frequently used type due to its higher refractive index and retention of the beneficial physical properties of polymethyl methacrylate (PMMA) lenses. Specialized forceps or an injector serve as the insertion devices for IOL implantation. The refractive power correction integrated into the newly developed multifocal IOL enables patients to see both near and far images on the retina. As a result, patients can achieve significant vision restoration without needing glasses after cataract surgery.[20]

El-Ashry et al. evaluated the changes in retinal nerve fiber layer measurement on OCT after phacoemulsification cataract surgery.13 In their study, the mean retinal nerve fiber layer thickness measured 84.9 ±16.5 microns, which increased to 93.0 ±17.6 microns postoperatively. This was statistically a significant increase.[21]

Mwanza et al. studied the effect of cataract removal by surgery, on the retinal nerve fiber layer and signal strength measurement on OCT.[22] They reported a 9.3% increase in retinal nerve fiber layer thickness and a 24.1% improvement in signal strength on OCT following cataract surgery. This enhancement in both signal strength and RNFL thickness was statistically significant. Additionally, they observed that the increase in thickness was more pronounced in patients with a preoperative signal strength of less than 6 compared to those with a signal strength greater than 6.

Dada and associates studied the effect of cataract surgery on retinal nerve fiber layer parameters as measured on scanning laser polarimetry.[23] This study demonstrated a statistically significant increase in retinal nerve fiber layer thickness, from 49.2 ± 14.1 microns to 56.5 ± 7.6 microns, four weeks after cataract surgery

Pauline and colleagues studied the changes in retinal nerve fiber layer thickness after cataract removal surgery and measured them by two models of SD-OC or spectral domain OCT (Cirrus HD OCT, (Carl Zeiss) and 1000Mark II, (Topcon)).[24]

The Cirrus HD OCT measured an increase in the thickness of retinal nerve fiber layer from 85.94 ±10.7 to 90.56 ±9.9 microns after cataract surgery, while the 1000 Mark II measured an increase in the thickness of retinal nerve fiber layer from 91.27 ±8.1 to 103.14 ±9.7 microns after cataract surgery.

Pareja-Esteban et al. have analysed parapapillary retinal nerve fiber layer behavior after cataract surgery.[25] However, in their study, the preoperative thickness of retinal nerve fiber layer was 90.71 ±19.93, which increased to 97.45 ±14.30 microns after one month of cataract surgery. This increase in the thickness was statistically significant.

Cataract affects the measurement of retinal nerve fiber layer thickness as measured on OCT; and cataract surgery enhances the ability of OCT to measure the changes in retinal layers.

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