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MISSION TO VISION IS THE LESSON OF PHACO EMULSIFICATION TO REMOVE CATARACT

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ABSTRACT

Phacoemulsification is a surgical procedure used to remove cataracts. It involves using ultrasound waves to break down the cloudy lens, which is then removed, and a new intraocular lens (IOL) is implanted in its place. This technique is considered a minimally invasive approach to cataract removal, leading to faster recovery times and fewer complications. Procedure: Small Incision: A tiny incision is made in the cornea (the clear outer part of the eye). Ultrasound Probe: An ultrasonic probe is inserted through the incision to break down the cataract lens into tiny pieces. Suction: The broken pieces are then gently suctioned out of the eye. IOL Implantation: A new IOL, a clear artificial lens, is placed in the capsule where the natural lens used to be. Benefits: Minimally Invasive: The small incision reduces the risk of complications and promotes faster healing. Precise and Effective: Phacoemulsification provides precise control over the cataract removal process, leading to better visual outcomes. Faster Recovery: Compared to older cataract surgery techniques, phacoemulsification results in quicker recovery times. High Success Rate: Phacoemulsification has a very high success rate, with a majority of patients experiencing improved vision. Alternatives: Laser Cataract Surgery: Some variations of phacoemulsification use lasers to assist in breaking down the lens, offering even greater precision. Manual Small Incision Cataract Surgery (MSIC): A technique that does not use ultrasound and relies on manual manipulation of the cataract lens.

KEYWORDS: IOL, MSIC, Cataract, Piezoelectric effect, Artificial lens.

INTRODUCTION

A cataract is a clouding of the lens in the eye, making it harder to see clearly. It can cause blurry vision, glare, and halos, especially at night. While often associated with aging, cataracts can also be caused by other factors like injuries, diabetes, or prolonged UV exposure. A cataract is a cloudy area in the lens of your eye (the clear part of the eye that helps to focus light).[1,2]

Figure 1: Eye & Cataract.

Cataracts are very common as you get older. In fact, more than half of all Americans age 80 or older either have cataracts or have had surgery to get rid of cataracts. The primary cause of cataracts is the natural breakdown of proteins in the eye's lens due to aging. This process, where proteins clump together, reduces the lens's transparency, leading to clouded vision. Other contributing factors include exposure to UV radiation, diabetes, smoking, certain medications, and genetic predisposition. Cataracts typically start developing

around age 40, though noticeable vision changes usually appear later, often after age 60. While age-related cataracts are most common, they can occur at any age, including in newborns (congenital cataracts) or later in childhood. The most common type of cataract surgery is called phacoemulsification. During this process, the rapidly vibrating tip of an ultrasound probe breaks up the cataract. Your surgeon then suctions out the lens, as seen in the top image. An outer housing of the cataract, called the lens capsule, is generally left in place. Phacoemulsification is a common surgical procedure for cataract removal that involves using ultrasound to break down the clouded lens and then aspirating it out of the eye. The "phaco" part refers to the lens (from the Greek "phakos") and "emulsification" means to break down or liquefy. This technique is widely used for cataract. This is also known as 'Phaco' and is the most common technique used for cataract removal today. It usually takes less than half an hour to remove a cataract through phacoemulsification, and requires only minimal sedation.[3-5] The most effective treatment for cataracts is cataract surgery, which involves removing the clouded natural lens and replacing it with an artificial lens. This is a day procedure and the only permanent way to address the vision issues caused by cataracts. In early stages, glasses or contact lenses can help temporarily, but surgery is essential for long-term vision correction. Phacoemulsification is a surgical technique used in cataract surgery. It involves using ultrasonic energy to break down the cloudy lens of the eye (the cataract) and then removing the fragments through a small incision, followed by the implantation of a new artificial lens. Phacoemulsification is a modern-day cataract surgery that employs ultrasound energy to emulsify the nucleus, vacuum to catch the nuclear material, and irrigation and aspiration for cortex and viscoelastic removal. A typical phaco machine consists of a handpiece, foot pedal, irrigation, and aspiration system.[6-8]

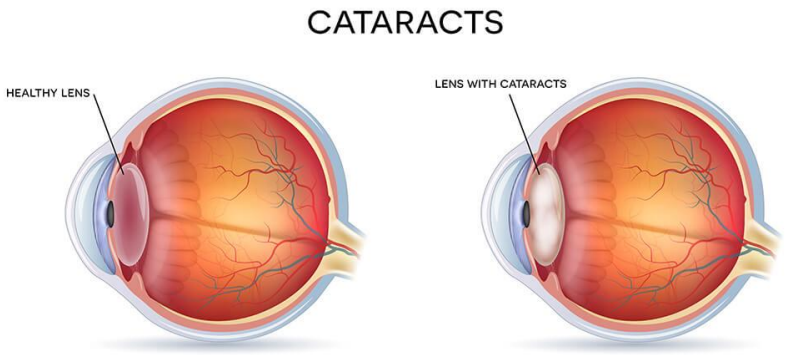

Figure 2: Cataract anatomy.

Phacoemulsification is a step in the cataract removal procedure. An ultrasonic device is used to break up (emulsify) the eye's cloudy lens. The most prevalent myth is LASER cataract surgery is a completely non-invasive procedure, while Phaco involves an incision and, therefore labelled to be traumatic. However, both procedures start with a micro-incision in the eye. Phacoemulsification, or phaco, is method of cataract surgery in which the eye's internal lens is emulsified using ultrasonic energy and replaced with an intraocular lens implant, or IOL. Small incisions which usually do not require stitches or sutures. Better vision results in more confidence, better mobility, and another psychological impact is the enormous relief from the fear of blindness. Most patients report a feeling of bright and clear vision, knowing that their worries were hitherto irrational. Both Phacoemulsification (Phaco) and Laser-assisted cataract surgery offer safe and effective vision correction, but they have some key differences. Phaco is a well-established, cost-effective method with a quick recovery, while laser surgery offers greater precision and potentially reduced complications but at a higher cost. The best choice depends on individual needs, preferences, and budget. The use of disposable equipments adds to the coat of the surgery. Lack of surgical skill and training in most of the medical institutions. Laser cataract surgery also uses phacoemulsification, but no ultrasonic instrument is used. Instead, the laser breaks up and softens the pieces of the lens. With this alternative method, there's less ultrasonic energy needed to remove the pieces, leading to a quicker process that disturbs fewer tissues in the eye. The most common cataract surgery is phacoemulsification, which involves using ultrasound waves to break up the cloudy lens for removal through a small incision. Phacoemulsification is the preferred method for most cataract surgeries due to its smaller incision size and faster recovery times compared to ECCE and ICCE.[9-11]

Figure 3: Phacoemulsification Inventor.

Charles Kelman is widely credited as the inventor of phacoemulsification, a revolutionary technique in cataract surgery. He developed the procedure in the 1960s, significantly changing how cataracts were treated and leading to smaller incisions, faster recovery, and better vision for patients. Charles David Kelman (May 23, 1930 – June 1, 2004) was an American ophthalmologist, surgeon, inventor, jazz musician, entertainer, and Broadway producer. Known as the father of phacoemulsification, he developed many of the medical devices, instruments, implant lenses and techniques used in cataract surgery. In the early 1960s, he began the use of cryosurgery to remove cataracts and repair retinal detachments. Cryosurgery for cataracts remained in heavy use until 1978, when phacoemulsification, a procedure Kelman also developed in 1967, became the modern standard treatment. Phacoemulsification, a common cataract surgery technique, involves using ultrasonic energy to break up the cloudy lens and then aspirate the fragments out of the eye. A small incision is made, a phaco probe is inserted, and ultrasonic waves break down the lens, which is then removed by suction. Finally, an artificial intraocular lens (IOL) is implanted to restore clear vision. Surgical methods used to remove cataracts include: Using an ultrasound probe to break up the lens for removal, called phacoemulsification. During phacoemulsification (fak-o-e-mul-sih-fih-KAY-shun), your surgeon makes a tiny incision in the front of your eye, called the cornea.[12-14]

The phacoemulsification system comprises three sub-systems: Ultrasound, aspiration, and irrigation.

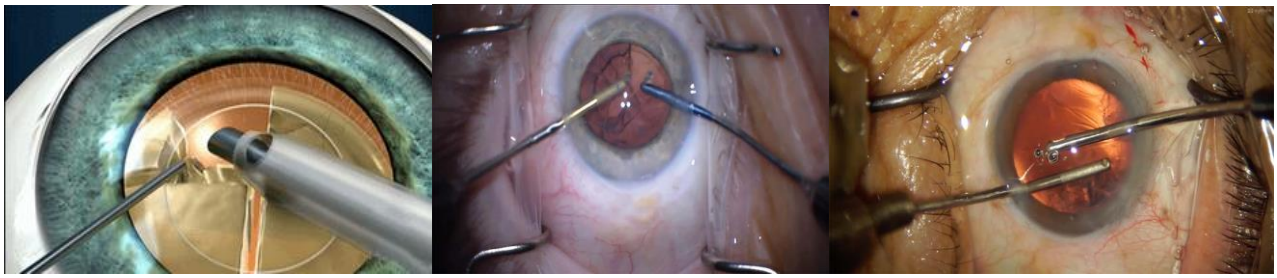

Figure 4: Phacoemulsification steps.

Ultrasound: The ultrasound component is used to break the lens down into particles small enough to be aspirated through the suction passages around the tip, which allows a very small incision for access. The incision is small enough that sutures are not needed for closure, and very little astigmatism is caused by healing of the wound in the cornea. The phacoemulsification handpiece has a tip which vibrates longitudinally at a frequency in the range of 27 to 60 kHz, with a stroke length of 60 to 150 micrometres. Power is adjustable by the operator as a percentage of full power, and indicates a variation in nominal stroke length. Actual stroke length may vary slightly depending on the density of the material it contacts, though some instruments use feedback to maintain nominal stroke by adjusting current, voltage or frequency. Nominal frequency is not adjustable. Both efficiency and heat generation are increased with higher frequency, and 40 kHz is considered a good compromise and is in common use. Most handpieces use piezoelectric crystals and the rest use magnetostrictive materials to generate the vibration. The handpiece is hollow and usually accommodates an aspiration line, and the vibratory transducer components are sealed into it. The handpiece is designed and constructed to be autoclaved between uses. The phaco tip is available in a variety of configurations, including a selection of tip angles to suit lens removal technique. Standard tip angles range between straight and 60 degrees, and more complex tips may have compound angles. The end of the tip may be round, ellipsoid, bent or flared. A variety of designs are intended to enhance cooling and irrigation, and to prevent burns. There are three hypothesised mechanisms of how the nuclear material is emulsified. One proposes that the tip acts as a chisel and removes material on the forward stroke, another proposes that ultrasonic energy is somehow involved, and the third proposes that the tip causes microcavitation bubbles on the retraction stroke, which collapse to exert high pressures on the materials very close to the bubble, which cause them to disintegrate.[15-17]

Figure 5: Cataract and removal.

Aspiration: The aspiration system is used to remove the emulsified lens tissue as it is broken down by the tip. This may be done through the handpiece, with the inlet orifice around the vibrating tip or through a separate aspiration tip, inserted through a smaller incision. The pump of the phacoemulsification system can be a peristaltic type or a vacuum transfer type. In peristaltic pumps aspiration flow rate and vacuum are independent. Vacuum is the suction force which holds cataract nuclear fragments against the phaco tip so that they can be emulsified, and draws the emulsion into the tip. Vacuum is the relative low pressure generated by the pump removing liquids and gas from the suction side, and the pressure difference between the vacuum pump reservoir and the ambient pressure at the inlet to the tip of the handpiece draws fluids through the aspiration ducting. When the inlet is occluded by solid material, such as a cataract fragment, the pressure difference holds the solid in contact with the tip while the ultrasonic vibration breaks up the solid to fragments small enough to pass into the aspiration ducting and be carried away by a current of ambient fluid, which must be replaced as fast as it is removed, to retain internal pressure and shape of the eye.

Irrigation: The three purposes of irrigation are to maintain intraocular pressure, carry lens particles out of the eye in the aspiration system, and to cool the phaco handpiece. Gravity feed of 650mm water column (75.5mm Hg) is typical. At this supply pressure, fluid enters the anterior chamber at a rate proportional to the rate at which it leaves due to aspiration and leakage. The pressure head is adjusted to suit anatomical variations and the health of the eye. Complications are less likely if the volume and pressure of the globe are maintained during surgery. This requires a balance between fluid input and output, which is a balance between irrigation, aspiration and leakage. Repeated partial collapses of the anterior chamber, and iris fluttering during removal of the nucleus are signs of inadequate fluid supply, which can be adjusted by changing the height of the gravity feed supply bottle. A height of 650mm above the eye is usually enough to compensate outflow almost immediately. During emulsification, the abrupt variations in flow at the start and end of emulsification of each fragment can cause fluctuations in volume and pressure, which can be corrected by control of the aspiration foot pedal. Sleeves for the phaco tip are standard accessories to insulate the wound surface from heat generated by the ultrasonic energy, and provide a route for irrigation.[18-20]

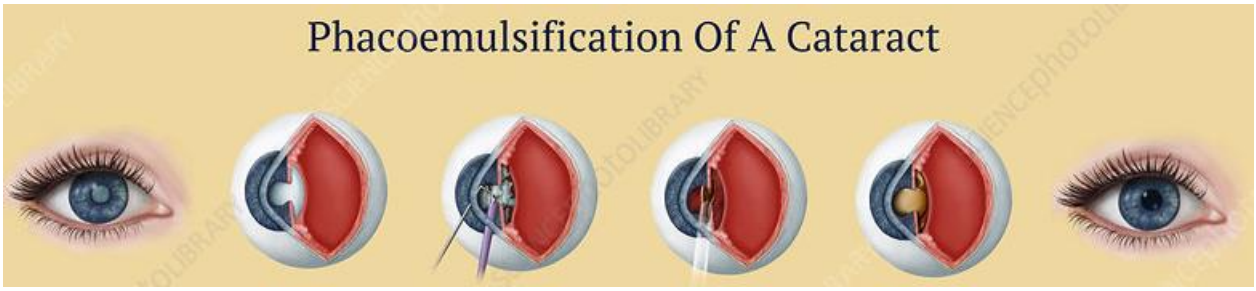

Figure 6: Mission to vision is the lesson of phacoemulsification to remove cataract.

CONCLUSION

Modern-day phacoemulsification has revolutionized cataract surgical outcomes. With the advent of innovative and premium intraocular lenses, cataract surgery has become the most commonly performed refractive surgery worldwide. The patient expectations and surgeon expertise and skill have also increased. Every eye deserves the best, and it is the duty of all cataract surgeons to perform the surgery ethically and give a perfect visual outcome. The patient should be educated about the risk and benefits of cataract surgery. The patient should be educated regarding the benefits of modern-day phacoemulsification. The clinician should help the patient fully understand the phacoemulsification technique, the types of foldable and premium intraocular lenses available, and which lens will benefit the patient most. In addition, in case of risk factors like Fuch's dystrophy, compromised endothelium, or small pupil cases, the patient should receive counsel regarding the need for additional instruments and devices like iris hooks and viscoelastic devices. In case of any intraoperative complication, the patient should be described in detail the intraocular mishap and what best can be done intraoperative or postoperatively to achieve a perfect visual outcome. Any patient requiring cataract surgery must be examined in detail by an ophthalmologist. Patients with high-risk factors for cataract surgery like pseudo exfoliation, limited pupillary dilatation, zonulopathy, history of uveitis, narrow-angle and shallow anterior chamber, subluxated cataractous lens, corneal opacity, secondary glaucoma, retinitis pigmentosa, etc. can be referred to a cataract and IOL surgeon with the skilled expertise to manage such cases. Pseudoexfoliation syndrome (PEX) is a systemic, age-related disorder characterized by the accumulation of an abnormal fibrillar material (pseudoexfoliative material) in various tissues, particularly within the eye. This material, which resembles dandruff-like flakes, can deposit on structures like the lens and iris, potentially leading to vision problems and glaucoma. A vitreoretinal surgeon should evaluate patients landing with intraoperative complications like zonular dialysis, posterior capsular tear, and vitreous prolapse postoperatively to rule out nucleus or cortex drop in the vitreous cavity other dreaded complications like retinal and choroidal detachment. Phacoemulsification has

evolved ever since its inception from anterior segment phaco to pupillary plane to posterior chamber phacoemulsification to safeguard the corneal endothelium, minimize complications and give a perfect postoperative visual outcome. The ophthalmic cataract surgeons and researchers have a crucial role in determining the ideal outcome. The nursing team plays a crucial role in preoperative investigations, counseling, intraoperative patient preparation, surgeon's assistance, postoperative patient counseling, and follow-up. The pharmacists also play a vital role in supplying the essential topical medications and guidance of the patients. In case of any complications, the vitreoretinal surgeon also plays an essential role in assessing the retinal status and need for retinal surgery like pars plana vitrectomy and lensectomy. In a nutshell, a multidisciplinary, coordinated effort is required for a perfect outcome after phacoemulsification.

REFERENCE

1. Davis G. The Evolution of Cataract Surgery. Mo Med, 2016 Jan-Feb; 113(1): 58-62.
2. Hennig A, Puri LR, Sharma H, Evans JR, Yorston D. Foldable vs rigid lenses after phacoemulsification for cataract surgery: a randomised controlled trial. Eye (Lond), 2014 May; 28(5): 567-75.
3. Al Mahmood AM, Al-Swailem SA, Behrens A. Clear corneal incision in cataract surgery. Middle East Afr J Ophthalmol, 2014 Jan-Mar; 21(1): 25-31.
4. Benjamin L. Fluidics and rheology in phaco surgery: what matters and what is the hype? Eye (Lond), 2018 Feb; 32(2): 204-209.
5. Yow L, Basti S. Physical and mechanical principles of phacoemulsification and their clinical relevance. Indian J Ophthalmol, 1997 Dec; 45(4): 241-9.
6. Sharif-Kashani P, Fanney D, Injev V. Comparison of occlusion break responses and vacuum rise times of phacoemulsification systems. BMC Ophthalmol, 2014 Jul 30; 14: 96-107.
7. Payne M, Georgescu D, Waite AN, Olson RJ. Phacoemulsification tip vacuum pressure: Comparison of 4 devices. J Cataract Refract Surg, 2006 Aug; 32(8): 1374-80.
8. Shi DS, Jensen JD, Kramer GD, Zaugg B, Stagg BC, Pettey JH, Barlow WR, Olson RJ. Comparison of Vacuum and Aspiration on Phacoemulsification Efficiency and Chatter Using a Monitored Forced Infusion System. Am J Ophthalmol, 2016 Sep; 169: 162-167.
9. Angmo D, Khokhar SK, Ganguly A. Intraoperative fracture of phacoemulsification tip. Middle East Afr J Ophthalmol, 2014 Jan-Mar; 21(1): 86-8.
10. Nejad M, Injev VP, Miller KM. Laboratory analysis of phacoemulsifier compliance and capacity. J Cataract Refract Surg, 2012 Nov; 38(11): 2019-28.
11. Hida WT, de Medeiros AL, de Araújo Rolim AG, Motta AFP, Kniggendorf DV, de Queiroz RLF, Chaves MAPD, Carricondo PC, Nakano CT, Nosé W. Prospective randomized comparative study between venturi and peristaltic pumps in WhiteStar Signature® phacoemulsification machine. Clin Ophthalmol, 2019; 13: 49-52.
12. Nayak BK, Jain EK. Comparison of corneal endothelial cell loss during phacoemulsification using continuous anterior chamber infusion versus those using ophthalmic viscosurgical device: randomized controlled trial. Indian J Ophthalmol, 2009 Mar-Apr; 57(2): 99-103.
13. Han YK, Miller KM. Comparison of vacuum rise time, vacuum limit accuracy, and occlusion break surge of 3 new phacoemulsification systems. J Cataract Refract Surg, 2009 Aug; 35(8): 1424-9.
14. Georgescu D, Payne M, Olson RJ. Objective measurement of postocclusion surge during phacoemulsification in human eye-bank eyes. Am J Ophthalmol, 2007 Mar; 143(3): 437-40.
15. Froehler MT. Comparison of Vacuum Pressures and Forces Generated by Different Catheters and Pumps for Aspiration Thrombectomy in Acute Ischemic Stroke. Interv Neurol, 2017 Oct; 6(3-4): 199-206.
16. Svensson B, Mellerio J. Phaco-emulsification causes the formation of cavitation bubbles. Curr Eye Res, 1994 Sep; 13(9): 649-53.
17. Bohner A, Peterson JS, Wright AJ, Mamalis C, Bernhisel A, Zaugg B, Barlow WR, Olson RJ, Pettey JH. Effects on phacoemulsification efficiency and chatter at variable longitudinal ultrasound settings when combined with constant torsional energy. J Cataract Refract Surg, 2020 May; 46(5): 774-777.
18. Wong T, Hingorani M, Lee V. Phacoemulsification time and power requirements in phaco chop and divide and conquer nucleofractis techniques. J Cataract Refract Surg, 2000 Sep; 26(9): 1374-8.
19. El-Moatassem Kotb AM, Gamil MM. Torsional mode phacoemulsification: effective, safe cataract surgery technique of the future. Middle East Afr J Ophthalmol, 2010 Jan; 17(1): 69-73.
20. Demircan S, Ataş M, Göktaş E, Başkan B. Comparison of 45-degree Kelman and 45-degree balanced phaco tip designs in torsional microcoaxial phacoemulsification. Int J Ophthalmol, 2015; 8(6): 1168-72.