بسم الله الرحمن الرحيم

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تم رفع هذه الرسالة بواسطة / سلوي محمود عقل

بقسم التوثيق الإلكتروني بمركز الشبكات وتكنولوجيا المعلومات دون أدنى مسئولية عن محتوى هذه الرسالة.

ملاحظات: لا يوجد

Introduction

With the recent cataract surgery development, phacoemulsification has become the main technique used. And its aim exceeds the removal of the lens opacity and restore vision to the reduction of the corneal endothelial cell loss during the surgery **(Sorrentino et al., 2017)**. It works by emulsification of the lens proteins by using high-intensity ultrasound energy. Exposure of hard lens proteins to ultrasound power breaks them down and results in softer and smaller particles that could be aspirated with a suction system. However, the ultrasound energy of phacoemulsification has a negative impact on corneal endothelial cells **(Bamdad et al., 2018)**. When performed by an experienced surgeon, endothelial cell loss (ECL) rates from 8.19% to 10.28% have been reported **(Heo et al., 2015)**.

The endothelium has two main functions: the formation of the Descemet membrane and the control of stromal hydration. The transparency of the cornea is assured by ionic pumps controlling a low level of stromal hydration **(Daus and Volcker, 1992)**. The number of endothelial cells about 4,000 cells/mm^2 at birth and decreases with age **(Yee et al., 1985 & Werblin, 1993)**. When the number of endothelial cells drops below a critical number of 450–800 cells/mm^2, corneal edema, corneal decompensation, and decreased visual acuity occur because the pump function is compromised **(Daus and Volcker, 1992)**.

Corneal endothelial cells are non-replicative, and the loss of these cells is only compensated for by the migration, enlargement, and increasing heterogeneity of the cells **(Waring et al., 1982)**. The mean endothelial cell count in the normal adult cornea ranges from 2000 to 2500 cells/mm^2, and the count continues to decrease with age. Previous cross-sectional studies have shown the normal attrition rate of corneal endothelial cells is 0.3-0.5% per year **(Yee et al., 1985 & Carlson et al., 1988)**.

Loss of endothelial function by the damage of endothelial cells can lead to increased corneal thickness and decreased corneal transparency because of increased stromal hydration due to compromised pump function **(Kohlhaas et al., 1997)**. Corneal decompensation is a rare but potentially vision-threatening complication after phacoemulsification surgery. Thus, the evaluation of risk factors for preoperative, intraoperative, and postoperative endothelial cell loss provides important information for the cataract surgeon.

Several studies have reported that some preoperative and intraoperative parameters influence the risk of endothelial cell loss after phacoemulsification. Specifically, advanced age, hard nucleus density, high ultrasound energy, long phacoemulsification time, the phacoemulsification technique, and large infusion volumes can increase the risk of endothelial cell loss after phacoemulsification **(Hayashi et al., 1996, Walkow et al., 2000, O'Brien et al., 2004 & Storr-Paulsen et al., 2008)**.

Phacoemulsification surgery is performed in a limited, confined space; however, securing adequate surgical space during an operation can decrease the risk of corneal endothelial cell loss as a result of the phacoemulsification procedure. Thus, anatomical and surgical factors, such as adequate anterior chamber depth, are important for preserving these cells from the mechanical and thermal damage that can occur during the procedure.

Aim of the Work

- Compare the loss of corneal endothelial cells after phacoemulsification according to different anterior chamber depths.
- Differences in cumulative dissipated energy, Endothelial cell loss among the anterior chamber depth groups.

Phacoemulsification

Definition:

A surgical technique to remove the nuclear portion of a cataractous lens using an aspirating and vibrating ultrasonic handpiece **(Allen, 2019)**.

Since its inception in the 1960s by Dr. Charles Kelman, phacoemulsification has developed the field of cataract extraction and become the standard of care for cataract removal **(Pandey et al., 2004 & Shah and Yoo, 2007)**.

Introduction:

Vision impairment is a common and potentially significant debility among the aged, afflicting 285 million people world-wide **(Weikel et al., 2014)**.

It has been estimated that over 68% of people over 79 years of age have some form of lens opacification or cataract **(McGwin et al., 2010).**

In 2007, WHO estimated that cataract is responsible for blindness in 39% of the 37 million blind people worldwide.

Since cataract surgery leads to improvement in eye vision in up to 90% of patients and 80% maintained vision improvement in 7 years, surgery remains the conventional treatment for cataract **(McGwin et al., 2003 & Lundström and Wendel, 2005)**.

The main objective in modern cataract surgery is to achieve a better unaided visual acuity with a rapid postsurgical recovery and reduced intraoperative and postoperative complications **(Mitchel, 2006)**.

Phacoemulsification has become the routine procedure for cataract extraction, where rehabilitation of the patient is very fast, associated with good visual outcomes. It offers the advantages of faster and more predictable wound healing, reduced discomfort to patients, fewer wound complications, and less changes of postoperative astigmatism than conventional ECCE **(Gonglore and Smith, 1998)**.

With advancements in cataract surgery technology, incision size, phacoemulsification energy, and endothelial cell loss have been reduced and phacoemulsification efficiency has been increased **(Lee et al., 2009)**.

Because PCS is able to achieve excellent visual and anatomical outcomes, it is one of the most routine operations in health care worldwide, with approximately 17·7 million procedures in 2018, **(Market Scope. 2019)** and is also associated with a reduction in morbidity and mortality **(Fong et al., 2013)**.

Overall perioperative complications can affect 4·2% to 8·6% of eyes operated on, and are associated with worse postoperative visual outcomes **(Zaidi et al., 2007 & Day et al., 2015)**.

Additionally, 7·0% to 16·2% of eyes have a postoperative absolute refraction error of more than 1 dioptre greater than planned preoperatively **(Gale et al., 2009, Bourne et al., 2013 & Lundstrom et al., 2018)**.

Phacodynamics

Handpieces and Tips

The standard phaco handpiece tip moves backwords and forwords when its crystals deform. In 2006, Alcon Surgical developed (OZIL) handpiece with the tip twist when stimulated at 32 KHz and produce linear movement when stimulated at 44 KHz. Moreover, if the shaft of the handpiece tip has a bend (Kelman tip), then a side to side motion develop. Later, Abbot Medical Optics (AMO) modified phaco needle to move lateraly and forwards at the same time in elliptical path (Ellips FX). Many tip designs (with usually 30° or 45° cutting tip angle) available eg. Straight with uniform diameter, kelman with 22° angled shaft 3.5 mm from tip (for enhanced emulsification and used as manibulator) or flared end with larger mouth for better holding and narrow inner 1–2 mm behind to decrease surge. **(Allen, 2019)**.

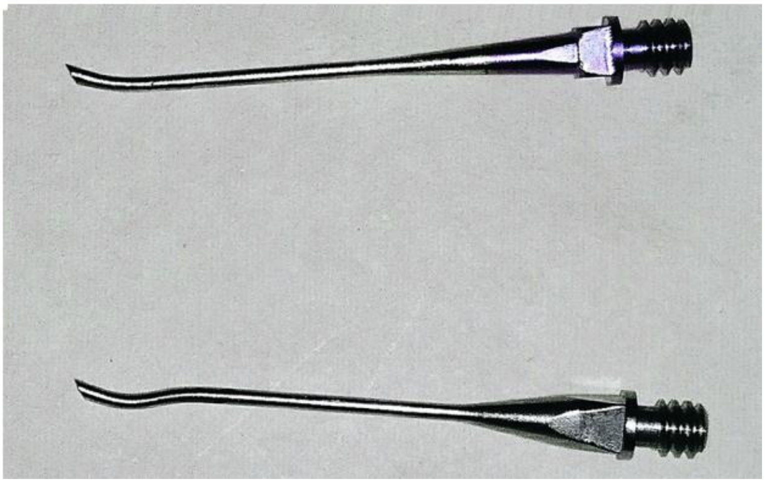

Figure (1): The 45-degree conventional tip with a 22-degree bend (top) and the new 45-degree balanced tip (bottom). Note the single bend in the conventional tip and 2 bends in the new balanced tip.

A completely new tip shape now present for torsional phaco (the "balanced" tip) (Fig.1) with reduction of the unwanted shaft movement and increasing of the maximum stroke length from 130 μ (in Kelman tip) to 190 μ This balanced tip performed phacoemulsification more efficiently, especially in hard cataracts requiring higher energy and prolonged phacoemulsification time **(Khokhar et al., 2017)**

Power adjustment of the phaco machine affects the stroke length of the tip but not its frequency and presented as percentage of the maximum tip travel, it is indicative only and non comparable between different phaco machines as relation between power percentage and stroke length differs between systems and may be nonlinear, also the minimum stroke length varies **(Allen, 2019)**.

The physical mechanisms that break up nuclear material when a phaco tip is used have been difficult to elucidate, with the direct impact of the tip breaks the frictional forces within the nuclear material. This direct effect is reduced, however, by the forward-propagating acoustic waves or fluid and particle waves generated by the tip, which tend to push away any piece of nucleus in contact with the tip **(Cohen e et al., 1979)**.

It is well established that the efficacy of torsional phacoemulsification is much higher than that of longitudinal phacoemulsification in terms of improved followability of the nucleus, decreased dispersion of lens material, reduced fluid use, and a reduction in the risk for thermal injury induced by the movement of the phaco tip **(Christakis and Braga-Mele, 2012)**.

Power Modulation

The power modulation started a long time ago with simple form (pulsed phaco). In 2001 AMO phaco machine start power modulation control. Phaco breakup into pulses or bursts helps repulsed material (caused by jack-hammer effect in traditional longitudinal Phaco) to come back into phaco tip during (off-period), also decrease the thermal effect on the corneal incision due to decreased frictional movement. At first, pulses had 50% fixed duty cycle and variable power ,also bursts were with fixed width and (mostly) power **(Allen, 2019)**.

Bausch & Lomb (Bridgewater, NJ) then now several machines allow almost infinite variation of both duty cycle (the ratio of on-time to off-time) and the length of the on-period. It has been shown that such power modulation significantly improves the “efficiency” of phacoemulsification (i.e., quicker surgery and reduced amount of phaco energy used), with no need to distinguish between bulsed and burest mode **(Chylack et al., 1993)**.

In addition the reduction of repulsion and thermal effect in torsional phaco make the power modulation less important **(Allen, 2019)**.

Pumps and Fluidics

The function of pump include holding nucleus onto the tip, remove the created debris and direct aspiration of soft parts of the nucleus **(Allen, 2019)**. According to the vacuum behavior the pumps classified into Peristaltic (flow) pumps, Venturi (vacuum) pumps and Hybrid pumps **(Salmon, 2020)**.

Peristaltic (flow) pumps

The pump (Figure 2) consists of a roller compressing a tube or membrane to generate flow. Recently new design of the pump with microprocessor controls result in a powerful control of the pump system. The flow rate in milliliters per minute (mL/min), is directly proportion with speed of events within the AC, with advanced recent machine the decreased aspiration during partial occlusion is compensated by readjustment of the pump **(Allen, 2019)**.

The vacuum is build up with occlusion of the tip followed by pump slowing until preset vacuum is reached, where the pump almost stops, **(Salmon, 2020)**. And the rate of vacuum build up is directly proportion to the flow rate (Fig. 3), **(Allen, 2019).**

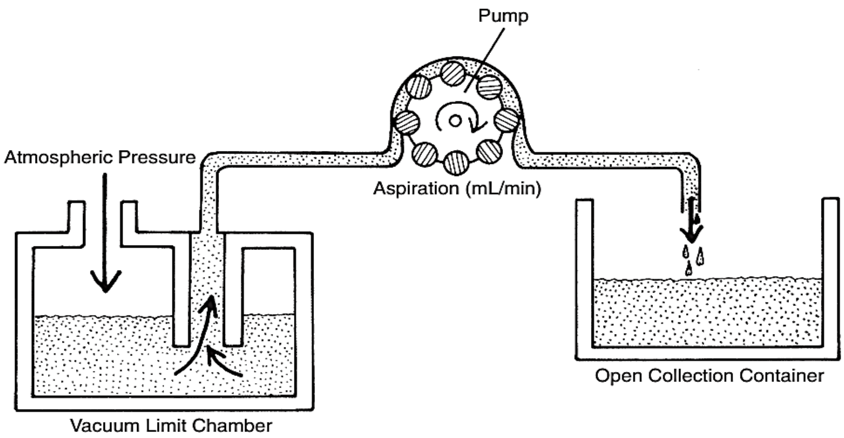

Figure (2): Peristaltic pump uses a rotating wheel with rollers to pinch off segments of the aspiration tubing, thereby moving separate columns of fluid through the tubing at a controlled rate of aspiration or flow. The vacuum limit is set separately and independently, limiting the maximal vacuum that is tolerated in the condition of complete occlusion of the aspiration line. The collection chamber, located after the vacuum limit chamber and the aspiration pump, is open to atmosphere.

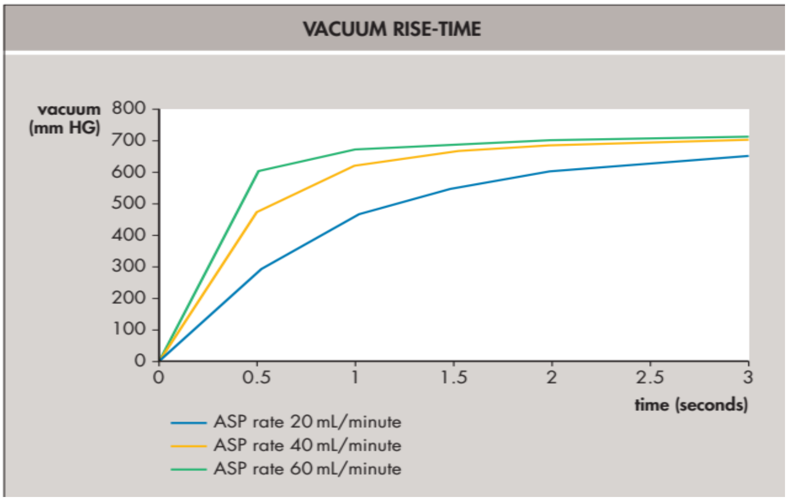

Figure (3): Vacuum rise-time as a function of aspiration rate. Graph showing the effect of increasing aspiration rate (pump speed) on the time to reach certain vacuum levels.

Venturi (Vacuum) pumps

The vacuum (Figure 4) is created by passage of compressed gas through a venturi connected to a rigid reservoir which is connected to the aspiration tubing. The vacuum level increase with increase the velocity of gas passage and vice versa. The pump allow only vacuum control and no independent setting of aspiration flow **(Fishkind et al., 2010)**.

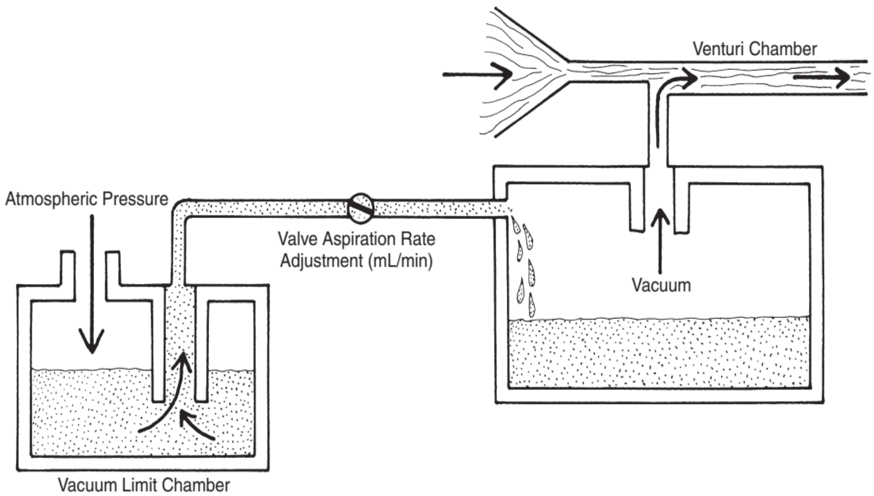

Figure (4): In a Venturi pump system, the flow of gas passed through tubing with increasing diameter creates a vacuum. The collection chamber is, therefore, a closed system. A separate valve can control the aspiration rate. A separate vacuum limit can be set, but a continuous internal vacuum is necessary to drive the aspiration of the fluid.

A modern modification makes the pump can act as both vacuum or flow pump, independent of their original design, and with digital input lead to maximum control and responsiveness. The primary example of this pump is the Allergan Sovereign Peristaltic pump. (Figure 5) **(Fishkind et al., 2010)**.

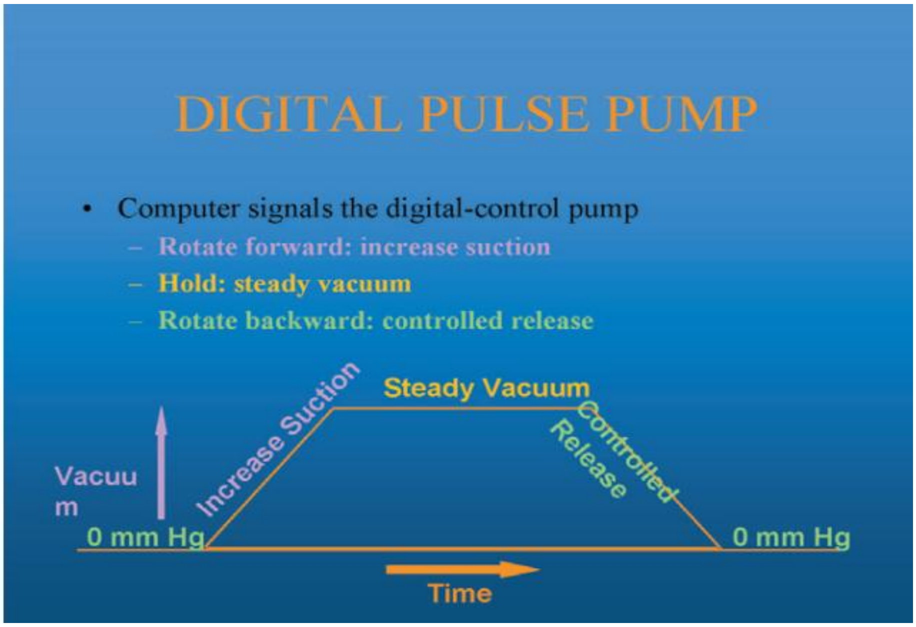

Figure (5): AMO Sovereign hybrid peristaltic pump.

Anterior Chamber Hydrodynamics

The term "flow" (aspiration flow rate) means evacuation flow out of the eye. In addition to the fluid pass throw the incisions which usually called the incision leakage flow. And the fluid flow into the eye is called "inflow".