ORIGINAL ARTICLE

Dynamic of the Phacoemulsification in various type of cataracts

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Abstract

Objective: The phacoemulsification has certain advantages which are small incision surgery reduce postoperative astigmatism: less inflammation and more rapid viual rehabilitation. The main Phacoemulsification is to remove the cataractous lens through a small incision. It is usually performed under local anaesthesia either with periocular infiltration or a retrobullar infiltration. Cataract is emulsified (liquefied) with ultrasonic energy through a 3.2. mm limbal incision with subsequent implantation of foldable intraocular lens. The 3.0 mm incision provides a more secure wound , less subjected to many of the complications of wound healing related to the large incision cataract surgery. Thus it leads to less astigmatism, short hospitalization and rapid return to normal life. The patients were followed up at 1st week, 3rd week, 6th week and 3rd month after the date of surgery.

Study Design: Comparative descriptive study.

Setting and duration: This study was carried out at Ophthalmology Department of Jinnah Medical College Hospital, Karachi from January 2007 to December 2009.

Subjects : Dynamic of the Phacoemulsification

Results: The results of Phacoemulsification of 50 eyes in 50 patients were analyzed for their phacodynamic aspects. These were divided into two groups of 25 eyes each. All underwent Phacoemulsification. Cataract with nuclear sclerosis grades 1 – 2 were included in group A while grade 3 and 4 were included in group B.

The aspects studies were the variations of different parameters of Phacoemulsification in different grades of nuclear sclerosis.

Conclusions: It is necessary for the surgeon to have a solid understanding of dynamics of the phacoemulsification such as Fluid Dynamics and Cutting Efficiency. Phacoemulsification is the method that results in most rapid return of visual function.

There is , however, a learning curve and every surgeon must gain necessary exoertise in phacoemulsification procedure and learn to avoid complications before he/she can safely employ this procedure for his or her cataract patients.

Keywords: Phacoemulsification, fluid dynamic, cutting efficiency

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Introduction:

The most exciting innovation in cataract surgery of the century is the technique of Phacoemulsification. It is a technique wherein a cataract is emulsified (liquefied) with ultrasonic energy through a 3.2. mm limbal incision with subsequent implantation of foldable intraocular lens. The 3.0 mm incision provides a more secure wound , less subjected to many of the complications of wound healing related to the large incision cataract surgery. Thus it leads to less astigmatism , short hospitalization and rapid return to normal life. (visual rehabilitation) Charles Kelman introduced Phacoemulsification as a new technique of cataract extraction in 1967.[1,2]

He performed his operation of breaking down of the cataractous lens nucleus by application of ultrasonic viberation through a 1.0 mm cylindrical titanium needle with sharpened edges. Phacoemulsification has come a long way since then. Many refinements have taken place both in the instrument and the basics of the technique.[3]

Modern machines have simplified and enhanced the technique considerably so that at present it is an easier , safer, simpler and more predictable procedure.[4] According to a poll in 1990 taken by the American society for cataract and refractive surgery, 52% of the ophthalmic surgeons felt that Phacoemulsification is the preferred method of cataract extraction.[5,2]

In this dynamics of Phacoemulsification. It is divided into two parts. The first consists of a brief review of the basics of the phaco machine and variables of techniques. The second part comprises of the original work, followed by the discussion and the conclusion drawn.

Methodology:

Patients Selection

Patients for this study were selected from the outpatient department of Ophthalmology, Jinnah Medical College Hospital, Karachi with cataract in their eyes.

Case selection criteria

The cases included in this study were selected according to the following criteria:

1. Eye with accurate perception and projection of light.
2. Eyes with clear corneas.
3. Eyes with normal anterior chamber.
4. Pupil that dilated greater than 7mm in diameter in pre-operative examination.
5. Cataracts with nuclear sclerosis grade 1 to 3.
6. Eyes with no abnormality dected in vitreous and retina on ultrasonic examination.
7. Eyes with normal range intra ocular pressure.

Case exclusion criteria

1. Eyes with subluxated or dislocated lenses.
2. Pupil that did not dilate more than 7mm after dilation.
3. Cataract with nuclear sclerosis grade 4 to 5.

The patients were thoroughly evaluated before proceeding for Phacoemulsification. A detailed history was taken including name, age, sex, occupation, address, diagnosis, brief history of illness, history of previous surgeries, history of any previous disease or trauma. History of medication and drug allergies was also taken.

After recording visual acuity in each eye patients were examined thoroughly on slit lamp. The lids were examined for the presence of entropion, ectropion or trichiasis. The precorneal tear film was examined for defects in the precorneal tear film that may create problems in keratomtery. The conjunctiva was carefully examined for congestion and discharge which was considered contraindication for immediate surgery. The cornea was carefully examined for any scars, irregularity or edema that might interfere with adequate visualization during Phacoemulsification. Signs of active intra ocular inflammation like ciliary congestion, keratic precipitates, flare and cells in anterior chamber were checked. Phacoemulsification , as other cataract extraction procedures, is contra indicated in any eye with active inflammation.[9] It should be performed after controlling the inflammation. The anterior chamber was examined for the presence of hyphema or hypopyon which are contraindications to any surgical procedure for cataract.[4] The iris was examined for the presence of rubiosis iridis. Its presence may lead to hemorrhage in the anterior chamber during Phacoemulsification. Presence of posterior synechiae were also looked for. Their presence was not considered as an absolute contraindication.[4,6] Synechotomy with viscoelastics and some modification in phaco procedure was required in each cases.[4,5] Examination of papillary shape and reaction was carried out . Lens examination was the special feature of slit lamp examination. Anterior capsular integrity was studies because the ruptured anterior capsule chould cause problems in anterior capsulotomy.[4]. Nuclear sclerosis was graded according to the colour of the lens nucleus and the age of the patient.

The patients pupils were then dilated and the fundus was thoroughly examined by 90 Diopter lens and indirect ophthalmoscope. The degree of papillary dilation was also measured and recorded. Finally intra ocular pressure was recorded.

Pre-operative investigation

Following pre-operative investigation were carried out in each patient:

Haematological Investigations included blood CP, ESR, and blood sugar fasting. Any evidence of infective focus was considered as contra indications to immediate sugery[1]. Surgery was also deferred in diabetics until the two hours post prandial sugar was below 200 mg%.

Biometry

K-reading and axial length of each eye was recorged and fed to a computer to calculate the intra ocular lens power, (IOL). IOL power was selected according to the requirement of the patient.

B-Scan

B-scan was also performed in selected cases.

Refraction was tried in both eyes where ever it was possible and required. The results were some times used to modify the power to decrease the anisometropia.

Instruments

The technical data regarding phaco machine is as follows:

a. Phacoemulsifier

The machine has fixed and pulsed phaco modes controlled through console and foot pedal. The machine provides linear control of ultrasonic power from 0 % to preset maximum. Pulsing of ultrasonic power is adjustable from 1 – 15 pluses per second. Phaco power is both panel control and surgeon control.

b. Cautery

The machine has adjustable power bipolar design cautery.

c. Irrigation / Aspiration

Linear irrigation and aspiration vacuum rises from 0-500 mm Hg with independent aspiration rate setting in the machine. Facility of instantaneous venting is available in the machine. Vacuum is provided by the peristaltic pump.

Operative Notes

The detailed operation notes were written in each case. All the operation notes contained following details:

a. Anesthesia
b. Type of incision
c. Details of anterior capsulotomy
d. Phacoemulsification details / phaco time, etc.
e. Details if the surgery was eventful.
f. Suture if used.
g. Drugs prescribed.

Pre-Phaco preparation of patients

Before the Phacoemulsification all the patients were briefed about the procedure and written consent was obtained. The pupil was dilated with 1% Tropicamide, one drop every thirty minutes for a total of three applications beginning two hours before surgery and then 1 drop of 10% Phenylephrine two times separated by 5 minutes. Topical flurbiprofen was installed 3 times 5 minutes apart half an hour before surgery.

All surgeries were performed under local anaesthesia.

2 % xylocaine with adrenaline and 0.5 % Bupivacaine in 1:1 ratio was used for retro bulbar injections and for facial blocks. A few cooperative patients were also operated under subtenon anaesthesia. After retro bulbar injection eye was briefly massaged with an eye pad to diffuse the medicine and to lower the intra ocular pressure (IOP).

Procedure

Blepharostasis was achieved by a lid speculum.

Bridle suture was not used in most of the cases. The wound and the side port were made in the clear cornea. Continuous curvilinear capsulorrhexis was performed by cystotome introduced through the wound after viscoelastic introduced. Hydrodissection was done until clear golden reflex was observed. The lens was then rotated to break (Hydrodelineeation) any adhesions left between capsule and the cortex.

The handpiece tip was introduced in bevel down position with foot pedal in position 1. Sculpting was done to create a cross trench in lens. The 4 pieces were then seprated with the help of a second instrument tintroduced through the side port. Each quadrant was removed by using appropriate phaco power, flow rate and aspiration. The cortex was removed by the phaco in pulse mode. Finally bits of the remaining cortical matter was handled by the simeco. The preciously calculated intra ocular lens (IOL) was then introduced through the incision after filling the AC and capsular bag with the viscoelastic.

If a foldable lens was used the incision was not extended but in other lenses the incision was enlarged accordingly. Finally the viscoelastic was removed from the anterior chamber (AC) and the capsular bag.

Usually the incision was closed by a single 10/0 suture but a few patients especially with foldable lenses were left without sutures. The second port was closed by hydrating the wound by the hydrodissection cannula. All cases received a subconjunctival injection of 20 mg gentamycin and 2 mg dexamethasone at the end of surgery. Pad and bandage was applied and patients were sent home or to the ward as appropriate.

1st post operative day

Patient's bandage was removed on the first post operative day. The vision was recorded and keratometery done. The patient was then examined under the slit lamp.

Follow up

The patients were followed up at 1st week, 3rd week, 6th week and 3rd month after the date of surgery.

Results:

The results of Phacoemulsification of 50 eyes in 50 patients were analyzed for their phacodynamic aspects.

These were divided into two groups of 25 eyes each. All underwent Phacoemulsification. Cataract with nuclear sclerosis grades 1 – 2 were included in group A while grade 3 and 4 were included in group B.

The aspects studies were the variations of different parameters of Phacoemulsification in different grades of nuclear sclerosis. In group A, 5 (20%) patients were male and 20 (80 %) were female. The average age was 53 years (Range 37 to 70 years) Table-1

In group B 17 (68 %) patients were male and 8 (32 %) were female the average age was 56 years (age varying from 48 to 65 years). Table-1.

Out of 25 eyes in group A, 10 (40% had grade 1 nuclear scelorosis, and 15 patients 60 % had grade 2 nuclear scelorosis. Table-2

In group B 17 (68 %) eyes had grade 3 nuclear scelorosis and 8 eyes (32 %) had grade 4 nuclear scelorosis. Table-2

As regarding anaesthesia all the patients in each group were operated under local anaesthesia. In group A, 12 patients underwent surgery in retrobular anaesthesia and 13 patients had sub Tenon injection. I group B, 22 patients underwent surgery in retrobulbar anaesthesia and 3 patients had sub Tenon anaesthesia. Table-3

Parameters of phacoemulsification

Phaco setting

In group A 30 º bevel needle was used in all patients. In the sculpting stage the phaco was used in continuous mode with linear control.

The ultrasonic power used was 70 % in 22 patients, and 50 % in 3 patients. Aspiration flow was approximately 20 ml/min in 15 patients and 12ml/min in 10 patients. The vacuum level was

Table 1: *Gender distribution*

Sex	Group A	Group B
Male	5	17
Female	20	8

Table 2: *Grading of Lens Hardness*

Group A		Group B	
Grade I	10 (40%)	Grade III	17(68%)
Grade II	15 (60%)	Grade IV	08(32%)

Table 3: *Peroperative anaesthesia*

Group	Total No	Sub-Tenon	Pere-Retro
A	25	13	12
B	25	03	22

set at 20mm Hg in 15 patients , 40 mm Hg in 9 patients and 300 mm Hg in 3 patients.

In the second stage that is the Quadrant stage. The Phaco power was used in pulse mode with linear control. The ultrasonic power used was 70 % and aspiration flow was 20 ml/min in all patients. The vacuum used was 140 mm Hg in 16 patients, 150 mm Hg in 6 patients and 300 mm Hg in 3 patients.

In third stage i.e. the eqinuclear stage.
The Phaco power was used in pulse mode with linear control. The average ultrasonic power used was 60 %, aspiration 20 ml/min and vacuum 18 mm Hg. The total phaco time required was from one to one and half minute in 16 patients and from two to three minutes in 9 patients of the group A.

In group B the phaco needle with 45º bevel was used in 10 patients and 30º bevel needle was used in 15 patients.

The phaco power was used in continuous mode with linear control during the sculpting stage. The ultrasonic power used was 70 % in 15 patients and 80 – 90 % in 10 patients. The aspiration flow was 10-16 ml/min in 13 patients and 20 ml/min in 12 patients.

The vacuum level was set at 20 mm Hg in 20 patients and was between 35 to 40 mm Hg in 5 patients.

In the second stage i.e. the quadrant stage.
The phaco power was used in pulse mode with linear control. The ultrasonic power used was 70 %. The aspiration flow rate was 20 ml/min in 20 patients and 24 ml/min in 5 patients.

The vacuum level was set at 140 mm Hg in 20 patients and 150 mm Hg in 5 patients.

In third stage that is the eqinucleus aspiration statge.
The phaco power was used in pulse mode with linear control. The ultrasonic power used was 70 %. The aspiration flow rate was 20 ml/min and the vacuum level was set at 140 mm Hg in all cases of group II.

The total phaco time used in group two was 1 to 2 minutes in 15 patients and 4 to 5 minutes in 10 patients.

Discussion:
Visual rehabilitation after cataract surgery has progressed through the eras of couching, intracapsular cataract extraction, extrqacapsular cataract extraction with intraocular lens implantation. With the acceptance of extracapsular cataract extraction and intraocular lens implantation, cataract surgery has grown more complex. Increasing dependence on techonology during and after the surgical procedure adds to the complexities.[7] Even after the implantation of an accurately calculated intraocular lens implant some patients are still satisified because of surgically induced astigmatism. So there was a room for improvement in this subspeciality of ophthalmology. With the advent of phacoemulsification technique, which allows the removal of the cataractous lens through a 3.2 mm self sealing-incision, the cataract surgery has achieved a level it deserves and would help to establish and maintain the elusive goal of excellence in the rehabilitation of cataract patients.[8] Phacoemulsification has been established as a safe, a traumatic and widely accepted method in the developed countries.[8,2] The hospital stay has been reduced from 4 to 5 days to a few hours. The six to ten week wait for glasses is, in large part, a thing of the past. Today's cataract patient feels slighted if

he cannot see well at the end of the first surgical week.[9,10] Of course, the precautions and limitations have not disappeared, but they are certainly less restrictive than they were a decade ago. With each successive day, we are introduced to the developments aimed at better, less limiting results for the cataract patients. Phacoemulsification is not a single entity but comprises of a number of maneuvers each having lots of minor details. The edge of a phaco surgeon over his colleagues is basically the understanding of phacoemulsification at this minor level. Perfection in them leads to the results desired by every cataract surgeon and of course the patient.

These steps start from the very beginning i.e. proper selection of the patient and elimination of patients which may not benefit from the procedure or where the risk of complication over balance the favorable out come. The prior anticipation of the density of the nucleus which will be encountered makes planning easier and more predictable.

The proper explanation to the patient plays a tremendous role in gaining patients confidence during the surgery, especially if one plans to operate under sun tenon anesthesia. Similarly prior understanding of the importance of the basic maneuver by the operation theatre staff helps in timely response and eliminates clumsiness. One must then be familiar by his own and his machine's capabilities. What flexibilities are available if needed to modify the procedure. The understanding of the variables such as phaco power, aspiration, vacuum, flow rate and bottle height etc, play an immense role in the success of the procedure.

The dynamic of the Anterior chamber and that of its particulates is important in deciding the alteration of the levels to fit the given scenario.In this study we compared the results of dynamics of phacoemulsification in various type of cataract at the department of ophthalmology, Jinnah Medical College Hospital, Karachi. The patients were divided into two groups of 25 patients each. The group A included cataracts of nuclear sclerosis grade 1 and 2 while group B had cataracts with nuclear sclerosis grade 3 and 4. All the patients underwent phacoemulsification.

Different parameters which were compared between the two groups and with other centres in the similar cataracts were the phaco power, its mode, the angulations of bevel of needle, the irrigation aspiration flow rates and the vacuum. In moderately dense nuclei Dillmen recommends high phaco power 50-80 % in continuous mode during the sculpting stage. His flow rates are 8-10 ml/min and vacuum preset at 25mm Hg.[11,12]

In cataracts with same density we were also comfortable with same settings except that our flow rates were slightly more. Our sculpting stage setting for the patients in group A were 70 % ultrasonic power in continuous mode. The irrigation aspiration flow rates were 12 ml/min in 40 % of the patients and 20 ml/min in the remaining of the group A cataracts. The vacuum preset was 40mm Hg in 36 % of the patients.

During the quadrant stage in moderately dense nuclei we used the ultrasonic power about 70 % in the pulse mode. The irrigation aspiration was kept at 20 ml/min in all patients. The vacuum was set at higher levels is 140 mm Hg in 16 patients, 150 mm Hg in 6 patients and 300 mm Hg in 3 patients.

This is very close to the internationally used settings. Dillman,[11] advocates high ultrasonic power in pulse mode with an irrigation ispiration rate of 20 to 30 ml/min and vacuum preset at the 150 mm Hg. In the removal of the eqinucleus the recommended setting are irrigation aspiration rate 15 to 20 ml/min vacuum 60 – 99 mm Hg and phaco power 50 – 70 % in pulse mode with linear control.

In this stage we used an ultrasonic power of 60 % in pulse mode, irrigation aspiration rate 20 ml/min and vacuum 80 mm Hg in all patients of group A. In the second group i.e. cataracts with denser nuclei slightly higher phaco power was required. In the sculpting stage about 70 % phaco power was used in 15 patients and 80 – 90 % in 10 patients. Dillman recommends 80 – 100

% phaco power in the continuous mode for the sculpting stage 11 in similar nuclei.

In another study Vasvada had used 100 % phaco power during the sculpting stage.[12] Since there is usually less chance of the total tip occlusion and hence the stoppage of the flow the risk of the heat increasing to dangerous level is minimal.

In our case the irrigation aspiration level was kept between 10 – 20 ml/min and vacuum was preset at 20 mm Hg in 20 patients and 35 – 40 mm Hg in 5 patients. The recommended irrigation aspiration level by the Dillman are 25 ml/min with vacuum with 8 – 10 mm Hg.[07,11] Vasavada also used a irrigation aspiration of 25 ml/min but a vacuum 0f 0 mm Hg.[5] With this vacuum Vasavada is quite justified by the fact that since there is usually no tip occlusion in the sculpting stage so the preset vacuum is never achieved. However we felt more comfortable with a preset level of about 20 mm Hg.

Our parameters during the second stage of the harder nuclear were ultrasonic power 70 % in pulse mode with linear control. The irrigation aspiration was set at 20 – 24 ml/min and vacuum preset around 140 mm Hg. Dillman recommendation for the same stage are irrigation aspiration rates 20 30 ml/min and vacuum at 100 – 150 mm Hg.[11]

As regarding the bevel angle of the phaco needle, about half were operated with 30 degree and remaining by 45 degree. This is slightly contradictory to the Dillman's recommendations who recommends a 45 – 60 degree bevel needle in harder nuclei.[7,11]

For the removal of the eqinucleus our settings were also as per recommendations that is, ultrasonic power 70 % in pulse mode, irrigation aspiration rate 20 ml.min and vacuum preset at 140 mm Hg.

It is therefore concluded that the internationally, recommended parameters for the phacoemulsification match more or less with each other as with our cases. However these have quite a flexibility allowing one to fit his own type of cataract.

Conclusions:

From this prospective study carried out at the Department of Ophthalmology, Jinnah Medical College Hospital, Karachi the following conclusions were drawn.

The idea patient for this operation is a person with medium dense cataract in an otherwise healthily eye that has deep anterior chamber and puple that dilates to or greater than 8 mm in diameter.

It is necessary for the surgeon to have a solid understanding of dynamics of the phacoemulsification that can be divided into two board catagories.

- Fluid Dynamics
- Cutting Efficiency

Fluid dynamics

The most poorly understood concepts among phaco surgeons are those involved with fluid dynamics of the phacoemulsification. These concepts are important in understanding followability and hollow holdability.

The followability can also be called attractability. It simply means that the ability to have phaco needle in the safest position possible to have desire element come to it as oppose to having to "go fish" for them.

The followability is the function of aspiration flow rate, the hold ability, on the other hand means the ability to hang on to a desire element once the phaco tip has been occluded. The hold ability is the function of vacuum. The phaco surgeon should be familiar with the difference between peristaltic and vacuum pumps.

The proper operating room setup, irrigation bottle height position and fixation of the globe are necessary for successful phacoemulsification. To perform excellent phacoemulsification, the surgeon must understand the functions of machine and able to trouble shoot problems effectively.

Cutting efficiency variables

The 30 % phaco needle is suitable for soft to medium or grate 1 & 2 type of nuclear sclero-

sis while 45 % needle is suitable for grade 3 & 4 nuclear sclerosis. Fifty to seventy % phaco power with continuous mode and with linear control should be used in removing the groove, in grade 1 to 2 of nuclear sclerosis. In the same grades of nuclear sclerosis, the phaco power with pulse mode and with linear control should be used during removing of quadrant and the last fragment of the lens.

80 – 90 % phaco power with continuous mode and with linear control is usually required during sculpting in grade 3 & 4. It is reduced with pulse mode and linear control in the quadrant stage and for the removal of the last fragment of the lens.

One should constantly observe the phaco tip while the ultrasound is on & beware of the speed at which the tip emulsifies the nucleus and keep the power setting at safe and desirable level.

Constant awareness of handpiece temperature is vital to avoid corneal burn and iris trauma. The anterior segment surgeons are advised to leave alone posteriorly displaced nuclear material and refer the patient to the vitreoretinal surgeon for the removal.

Phacoemulsification offers significient safety because eye remains pressurized during the procedure.

The cataract extraction by the phacoemulsification is the method that results in most repid return of visual function.

There is , however, a learning curve and every surgeon must gain necessary expertise in phacoemulsification procedure and learn ato avoid complication before he / she can safely employ this procedure for his or her cataract patients.

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