

Managing Hard Cataracts Using Bimanual "Hole Drilling" Phacoemulsification

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Abstract: Purpose: To describe and evaluate a new surgical technique aimed primarily at managing cataracts of nuclear grades 3-4. Patients & Methods: Thirty-two eyes of 32 patients underwent bimanual phacoemulsification using a new technique termed "hole drilling." This technique was developed in an attempt to weaken the nucleus of the cataractous lens consequently enabling the surgeon to fracture it easily and rapidly. Using a sleeveless tip and irrigating chopper, 4 vertical holes are drilled up to 2/3 of the nuclear depth. After a shift in machine parameters, the chopper is engaged in one hole and the phacotip in another and the nucleus can be split easily along these weakened lines making use of high vacuum. The maneuver is repeated sequentially resulting in nuclear pieces that can be efficiently emulsified. Pre-operative data was collected and included age, sex, and nuclear density. In this series, 24 patients were graded at 3+ nuclear density (group A) and 8 patients were graded at 4+ or above (group B). Intraoperative parameters studied within the patient series included infusion bottle height, vacuum setting, flow rate, phaco power, effective phaco time (total phaco time in sec X average phaco power %) ² and cumulative dissipated energy (total phaco time in minutes X average phaco power % / 100 = CDE) ³. Results: A preliminary series including 32 eyes with nuclear cataract graded 3 and above, have been operated upon using the technique described. Effective ultrasound time ranged from 2 to 14 seconds with an average of 7.98 seconds. Cumulative dissipated energy ranged from 0.0003 to 0.0023, with an average of 0.001 and SD +/- 0.0006 Conclusion: We found this bimanual technique to be useful in managing hard cataracts ensuring nuclear disassembly in an effective and safe manner.

Key words: Hard Cataracts, Bimanual "Hole Drilling and Phacoemulsification

INTRODUCTION

Managing denser grades of cataracts frequently encountered in developing countries has long been considered a challenge. Bimanual phacoemulsification is slowly gaining ground as a worthy competitor to conventional co-axial phacoemulsification. However, one of the drawbacks of bimanual or micro-incision cataract surgery (MICS) is that it can be somewhat slower when compared to co-axial phacoemulsification. This is problematic especially when dealing with harder cataracts. This is related to the fact that we are using micro-tips and utilizing lower effective power while adhering to the surgical techniques similar to those employed in conventional coaxial phacoemulsification (Tsuneoka *et al.*, 2002). By modifying existing techniques while performing bimanual surgery, a more effective result can be achieved. The aim of this study is to evaluate a new technique of phaco emulsification designed for MICS surgery in hard cataract surgery.

MATERIALS AND METHODS

Thirty-two eyes of 32 patients were prospectively enrolled in this series. Inclusion criteria included nuclear cataract graded 3-4 in patients above the age of 50. Patients with co-existing ocular pathology were excluded from this study.

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Pre-operative data was collected and included age, sex, and nuclear density. In this series 24 patients were graded at 3+ nuclear density (group A) and 8 patients were graded at 4+ or above (group B).

Intraoperative parameters studied within the patient series included infusion bottle height, vacuum setting, flow rate, phaco power, effective phaco time (total phaco time in sec X average phaco power %) (Hoffman *et al*, 2002) and cumulative dissipated energy (total phaco time in minutes X average phaco power % / 100 = CDE) (Singh *et al*, 2001).

Technique:

The "Hole drilling" technique was developed in an attempt to weaken the nucleus of the cataractous lens consequently enabling the surgeon to fracture it easily and rapidly. Two 1.2 mm paracenteses were made and viscoelastic was injected into the anterior chamber. A 5-6 mm anterior continuous curvilinear capsulorhexis was carried out using a forceps or needle and careful hydrodissection performed. The sleeveless phacotip was then introduced through the micro-incision after inserting the irrigating chopper through the other paracentesis.

Phase I Phacoemulsification Parameters Were Set as Follows:

Duty cycle 15% on 85% off cycle, frequency 20 to 30 Hz, power 50%, vacuum 50 mmHg, flow rate 28 CC/min, infusion height 120 cm (parameters refer to machines used in the series: Geuder S3 and Orтели Catarex, Sovereign). With these settings the phacotip was used to drill 3-4 holes into the bulk of the central nucleus aiming at creating one hole in each quadrant (Fig 1, fig 2 a and b). Each hole was drilled to within 2/3 of the nuclear thickness. These holes were made with a rotary movement of the hand piece while activating power to maximum (position 3 of the foot pedal). With the tip buried into the nucleus the corneal endothelium is additionally protected by the nuclear bulk despite the low ultrasound power used.

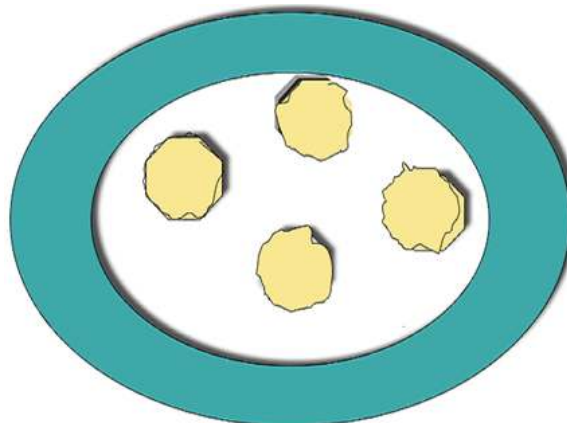


Fig. 1: Diagrammatic representation showing 4 holes drilled, one in each quadrant.

Phase II Phacoemulsification Parameters Were Set as Follows:

Once the holes were created the machine settings were changed to 8-10 Hz frequency, vacuum 250-300mmHg, while utilizing same duty cycle, flow rate and infusion height. Now, the chopper was engaged in one hole and the phacotip in another and the nucleus was split easily along these weakened lines making use of the high vacuum. Utilizing what we term "cleavage planes" the nucleus was easily split along these lines (Fig 3). The maneuver was repeated sequentially resulting in smaller nuclear pieces that could be easily, rapidly and efficiently emulsified (Fig 4).

Intraoperative data was coded and the data was summarized using the mean and standard deviation for quantitative variables and percent for qualitative data.

RESULTS AND DISCUSSION

Results:

This preliminary series included 32 eyes with nuclear cataract graded 3+ and above. All patients underwent surgery using the hole drilling technique described.

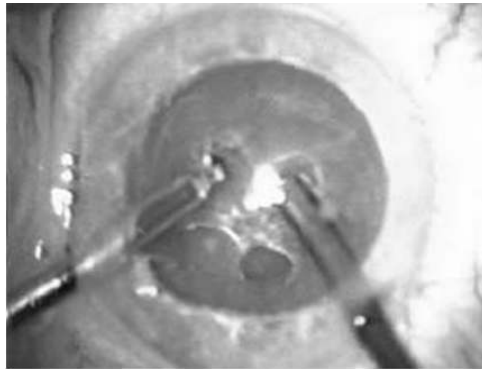


Fig. 2a: Four holes are seen drilled to 2/3 nuclear depth, one in each quadrant.



Fig. 2b: Deepening of the holes



Fig. 3: Cracking and removal of the first quadrant

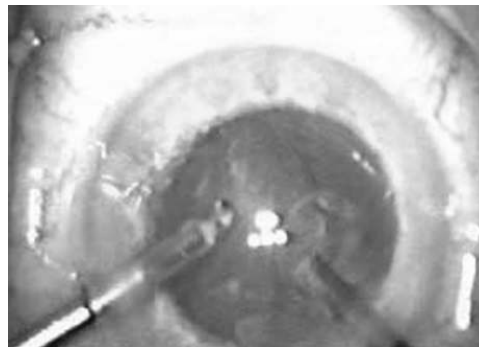


Fig. 4: Quadrants are easily grasped using high vacuum and emulsified

Table 1: showing mean EPT in both groups

Subgroup	Mean effective phaco time (seconds)	+/-SD (seconds)	Mean difference
A	6.88	3.91	5.62 sec
B	12.5	1.78	

Table 2: showing mean CED in both groups

Subgroup	Main cumulative dissipated energy	+/-SD (seconds)	Mean difference
A	0.001	0.0006	0.001
B	0.002	0.0003	

Pre-operative Clinical Data:

Pre-operative data showed that the age of patients within the group ranged from 51-80 years with a mean age of 60.75 years (SD +/- 7.41 years). Twelve males and 20 females were included. Nuclear density ranged from a 3+ nuclear density (24 eyes) group A. to a 4+ nuclear density (8 eyes) group B.

Intra-operative Data:

Infusion bottle height was set at 120 cm in both phases.

Vacuum during phase I of the procedure ranged from 30-100 mmHg with a mean vacuum of 61.5 mmHg. After parameter adjustments for phase II vacuum ranged from 300-350 mmHg with a mean vacuum of 314 mmHg .

Flow rate ranged from 24-30 ml/min in phase I. During phase II flow rate ranged from 20-30 ml/min.

Phaco power was set at 70% during phase I. During phase II phaco power ranged from 50-60%.

Effective phacoemulsification time (EPT) ranged from 2 to 14 seconds with an average of 7.98 seconds (SD +/- 3.81 sec). It should be noted that in group A, mean effective phaco time was 6.88 sec (SD+/- 3.91 sec). In group B, mean effective phaco time was 12.5 sec (SD+/- 1.78 sec). This difference was considered statistically significant (p=0.0005; 2-tailed test), (Table 1).

Cumulative dissipated energy ranged from 0.003 CDE to 0.0023 CDE (SD +/- 0.0006 CDE). The mean CDE was 0.001 (SD+/- 0.0006) in group A and 0.002 (SD+/- 0.0003) in group B. Again when CDE was compared between group A and group B, a statistically significant difference was noted (p=0.0005; 2-tailed test), (Table 2).

The total nucleus management time ranged between 1.4 to 3.3 minutes.

Discussion:

Techniques used for managing the hard nucleus vary. Most surgeons will agree that obstacles are encountered at virtually all stages of the surgical procedure. These include, difficult visualization in cases where the red reflex is absent, difficulty in cracking due to the leathery nature of the lens (Vanathi *et al*, 2001) and increase overall time for nuclear disassembly, thermal injury and endothelial cell loss to name a few (Singh *et al*, 2001). Many techniques for conventional co-axial phacoemulsification in hard cataracts have been reported including the Crater and Chop technique where a large crater is created approximately 6.0 mm diameter by down slope sculpting up to 90% of nucleus thickness, leaving the outer nuclear rim intact. High vacuum is used and small wedge-shaped pieces are created with a chopper. These small pieces are emulsified in the space created by the crater. The Phaco Slice and separate is another example of a co-axial technique that is reported to work in a broad range of nuclear densities with less ultrasound time (Arshinoff, 1999).

Surgeons are constantly investigating new techniques to reduce phaco time and power thereby limiting energy expenditure and minimizing trauma during surgery. Investigators have identified that modulations in power delivered to the eye during surgery ultimately affect the energy delivered to the eye (Fine *et al*, 2004).

Our technique uses MICS phaco-technology which has the advantage of less effective ultrasound power, and smaller wounds. Coupled with the capacity for high vacuum and modifications in aspiration flow rate and energy delivery, bimanual phacoemulsification becomes more efficient with significantly lower mean phacoemulsification time (Samuel and Randall, 2001; Alio *et al*, 2005). With these advantages comes the potential for use of new intraocular lens technology, new micro-instruments and optimization of machine fluidics (Alio *et al*, 2005).

This technique also merges several preexisting techniques with a new concept of hole drilling or "vertical grooving". With the divide and conquer techniques, grooving is used to create lines along which the hard nucleus can be cracked. Dividing the nucleus into 2 or 4 manageable pieces is one of the most vital initial steps towards successfully completing the surgery (Wong *et al*, 2000). Conventional grooving techniques,

however would possibly deliver more energy than the vertical hole drilling technique suggested here. Using the technique described above, creating holes in each quadrant with the rotatory movement of the tip helps burrow the tip inside the depth of the nucleus. The remaining bulk around the tip protects the corneal endothelium. Bimanual techniques with smaller incisions and utilizing sleeveless phacotips use much lower and more efficient ultrasound power without an increase in heat delivered to the wound (Tsuneoka *et al*, 2001).

We also noted that when the holes are drilled to within 2/3 of the nuclear thickness this aids in weakening the hard nucleus allowing the surgeon to fracture the nuclear bulk into quadrants easily despite the gummy nature of hard nuclei. The smaller pieces resulting from fracture can be dealt with rapidly using the small tip and low power used in bimanual techniques.

Chopping techniques vary and many can be used successfully to manage harder grades of cataracts. However, in classic chopping techniques, excessive manipulation is sometimes needed, especially when chopping from the equator to the center. Chopping techniques that utilize chopping from the anterior pole of the lens to the posterior pole of the lens such as the karate chop technique overcome this weak point (Nagahara, 1999). Our technique uses manipulations during nuclear disassembly very similar to those used in the karate phaco chop however, by using the holes created, cracking hard nuclei becomes easier than if it were attempted by chopping alone. The holes give the surgeon an excellent "grip" of the nucleus providing better control over the splitting stage of the nuclear disassembly.

Reports of various bimanual techniques include manual phaco bisection or trisection for softer cataracts (Alvarez and Abreu, 2000). Manually dividing harder lenses however would not be considered feasible and a bimanual technique such as that described here can achieve nuclear disassembly in cataracts graded 3 + and above. Other authors have also reported success in managing harder grades of cataracts using low ultrasound microincision cataract surgery or *Lus MICS* (Alio *et al*, 2005).

In order to fully appreciate the value of the creation of holes in the nucleus prior to the cracking process, several explanations can be considered.

Use of Rotational "Spiral" Movement While Drilling:

Performing rotation while drilling into a material along the axis of drilling makes the drilling easier and faster. This can be explained by the following:

- Rotation along the axis of drilling causes "sheer forces and stress" on the material layers and molecules in addition to the pressure or impact force applied on it. This accelerates the breakdown of the bonds between the layers and each other, unlike using the impact force alone for breaking down bonds between material layers
- Rotational action causes momentum between neighboring molecules and each other, thus breaking the bonds between the individual molecules within the same layer.

The Tensile Stress Technique of Concentrated Stress for Breakdown:

According to Hook's law, the amount by which a material body is deformed (the strain) is linearly related to the force causing the deformation (the stress), by using the hole drilling technique the surgeon can cause a material to crack if it reaches a "tensile strength" such that it cannot remain intact and collapses; this can be done by what's called "concentrated stress" and it is done by creating several holes along the cross-section of the body, or notches along their lines. These holes create a concentrated stress around the deformed spot, which causes a breakdown of the material's molecules and layer's bonds. Accordingly, this is seen after creation of the holes and the behavior of the nucleus as it breaks down into stable smaller pieces.

Suggestions to Aid the Suction of the Fluid:

- We suggest that the two ports at the sides could be moved to one hole at the bottom of the probe.
- The size of that port should be 1.5 times the original size of the port to increase the velocity or the rate of flow of fluid exiting the irrigating port. This should be balanced against suction and may aid the flow of emulsified material towards the tip.
- An added advantage would be the backward flow of fluid effectively pushing back the posterior capsule during the cracking process.

Conclusion:

The concept of drilling 4 holes, subsequently weakening the hard nucleus and then fracturing the nucleus along cleavage lines is a simple and reproducible technique that saves time and energy. Although bimanual techniques make use of different instruments and require dexterity in using both hands with equal proficiency, we found that by modifying existing phacoemulsification techniques, bimanual surgery can be as efficient as, if not superior to, co-axial techniques when addressing hard cataracts.

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