Evaluation of Different Modalities of Phacoemulsification in Management of Hard Cataracts

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Abstract

**Purpose:** To evaluate the efficacy, Intraoperative performances and postoperative outcomes of cataract surgery performed with Torsional and conventional linear phacoemulsification in hard cataracts.

**Methods:** Of 50 patients who had senile hard cataracts, 60 eyes were operated on using the Infiniti Vision System. Preoperative examinations (Slit Lamp Examination, Visual Acuity, and IOP) were performed for each patient. Cataracts were classified into hard, according to the Lens Opacities Classification System III grading of nucleus opalescence. Eyes were randomly classified into 2 groups. Group A 30 eyes were randomly assigned to Torsional phaco-mode. Group B 30 eyes were randomly assigned to conventional linear phaco-mode. Intraoperative parameters, including Ultrasound Time (UST) and Cumulative Dissipated Energy (CDE), Percent of Equivalent US Time in position 3 (USTEPiP3), and Mean Balanced Salt Solution (Estimated Fluid used), (which were automatically calculated by the device), were evaluated. Intraoperative complications and difficulties were recorded. Postoperative Corneal Edema, Best Corrected Visual Acuity (BCVA) were checked after one week.

**Results:** The mean age of patients in the Torsional and conventional linear groups were 60.5±7.8 years and 61.4±5.4 years (p=0.643), respectively. Preoperative BCVA (log MAR) [0.78±0.09 in group A and 0.83±0.11 in group B] and mean grading of Nuclear hardness showed no difference in both groups. The differences in Ultrasound Time (UST) and Cumulative Dispersed Energy (CDE) in both groups were statistically significant (p<0.01). The mean UST and CDE were lower in the Torsional Group (88.6±3.09 sec & 19.13±1.2 respectively) than in the Conventional Linear US group (115.4±5.4 sec & 32.36±3.45 respectively). The Percent of Mean Total Equivalent Time in Position 3 (USTEPiP3), Mean Balanced Salt Solution (Estimated Fluid Used) and Mean Aspiration Time were lower in group A than Group B. In group A there were 2 cases of posterior capsular rupture, while 3 cases were encountered in group B. Early Postoperative Corneal Edema was more obvious in the Conventional Linear Group than the Torsional Group and last for 3 days only. The mean BCVA (log MAR) after one week was 0.15±0.13 in Group A and was 0.23±0.05 in Group B.

**Conclusions:** The Torsional mode provides an effective and safe method for cataract removal as it uses less US energy and time as compared to Conventional Linear Phacoemulsification, in the early postoperative stage. However, the final visual outcome was similar for both modalities. Both US modes are effective in management of grades III and IV cataracts.

**Key Words:** Torsional phacoemulsification – Conventional linear phacoemulsification – Hard cataract.

Introduction

PHACOEMULSIFICATION is the main procedure of modern cataract surgery. Ultrasonic (US) energy during phacoemulsification can carry the risk of endothelial cell loss and tissue damage, especially in hard cataracts. In the conventional linear US mode, the phaco tip moves forward and backward, and the US energy comes from longitudinal movement of the tip. The jackhammer effect plays an important part, and the cavitation effect plays minimal role in longitudinal phacoemulsification. The longitudinal mode can produce a repulsion effect, because the phaco tip pushes the nucleus away when it moves forward [1].

In January 2006, Alcon Surgical incorporated OZil Torsional into the Infiniti Vision System. The OZil Torsional system (Infiniti, Alcon, Fort Worth, TX) is a hardware and software upgrade which includes a dedicated hand piece that produces side-to-side rotary oscillations of the phaco tip. Comparing with the jackhammer motion in conventional linear phaco, the improved OZil Torsional oscillation sheers the lens material with virtually no repulsion, thereby dramatically reduced phaco energy required for lens removal without compromising efficiency. Torsional works at a lower frequency of 32 kHz than the 40–45 kHz in conventional linear phaco and theoretically reduces efficiency in lens removal, especially with hard nucleus [2].
In previous reports, the Torsional phacoemulsification using OZil Torsional equipment provided a lower level of US time and energy, and more effective phacoemulsification than the conventional linear methods [3,4].

Aim of the study:
The aim of this randomized prospective clinical comparative study is to evaluate the safety, efficiency, Intraoperative performance and postoperative clinical outcome using Torsional and Conventional Linear US mode in hard cataracts (Grade III&IV).

Patients and Methods

This study was done from May 2010-Dec. 2011. Sixty eyes of 50 patients (23 males, 27 females), having elective phacoemulsification and IOL implantation, were enrolled in this clinical study. The average age was 61.3±5 years (range 55 to 72), 10 patients had bilateral phacoemulsification.

Inclusion criteria:
Patients aged 50 years or older, with the diagnosis of age-related cataract, have been included in the study. Patients who had other ocular or systemic disorders affecting vision were excluded. These included patients with diabetic retinopathy, glaucoma, age-related macular degeneration, uveitis, corneal endothelial disease or previous intraocular surgery.

Preoperative evaluation:
First, patients are enrolled and informed consent is obtained from them. Standard preoperative ophthalmological examinations including: Best Corrected Visual Acuity (BCVA) using log MAR standards, intraocular pressure (IOP) measurement by Goldman’s Applanation Tonometry, Slit-Lamp Evaluation, Lens Nucleus Density Grading according to the Lens Opacities Classification System II (LOCS II) [5], and fundoscopic examination. Eyes with nuclear opalescence (NO) grades between 3 and 4 were included in the study.

The eligible eyes were randomly classified into two groups, Group A 30 eyes done using Torsional US mode phacoemulsification, Group B 30 eyes done using Conventional Linear US mode phacoemulsification only.

Surgical technique:
All surgeries were performed using the Infiniti Vision System (Alcon Laboratories), and the same US and fluidic settings were used by a single surgeon. All patients received periorcular anesthesia [6]. http://www.ncbi.nlm.nih.gov/pubmed/1895230 A 2.8mm self sealing limbal incision was made at 12 O'clock and a paracentesis using 15° blades performed at about 60° from the main incision. Sodium hyaluronate 3.0%-chondroitin sulfate 4.0% (Viscoat, Alcon Surgical, Fort Worth, TX) was used to reform and stabilize the surgical planes and protect the corneal endothelium. A 5.5 to 6.0mm continuous curvilinear capsulorhexis was performed with a bent 27-gauge needle.

A routine phaco-chop technique [7] was used either with the Torsional continual mode or Conventional Linear US pulse mode (60p/sec). The micro tip 0.9mm angled Aspiration Bypass System phaco tip (15 degrees) was used with a standard setting. For the Torsional mode, 100% amplitude was selected. For the Conventional Linear US pulse mode, a maximum power of 70% and pulse frequency of 60 pulses per second were selected. The vacuum limit was 350mmHg, and the aspiration flow rate was 35mL/min. Balanced Salt Solution was used as irrigation solution. The parameter settings are shown in Table (1).

Table (1): Parameters for torsional and conventional linear ultrasound groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Group A</th>
<th>Group B</th>
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<tbody>
<tr>
<td>Torsional amplitude</td>
<td>100%</td>
<td>0</td>
</tr>
<tr>
<td>Ultrasound power (%) (burst)</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>Vacuum limit (mm Hg) (fixed)</td>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>Aspiration flow rate (cm³/min) (fixed)</td>
<td>35</td>
<td>35</td>
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The main system parameters were recorded. Ultrasound Time (UST), and Cumulative Dissipated Energy (CDE). US Time represents the total time in seconds that U/S (or OZil) remained active [8]. Other parameters recorded includes the Percent Of Average Ultrasound Amplitude in Position 3 (USTEPiP3) (This parameter evaluates Torsional US energy in position 3), Mean BSS (Estimated Fluid used) and Mean Aspiration Time which were automatically calculated by the device.

An intraocular lens was inserted through the 2.8mm incision into the bag. The limbal wound was not sutured.

Intraocular difficulties and complications were recorded.

Patients were examined on postoperative days 7, and 30. The postoperative corneal clarity and Best Corrected Visual Acuity (BCVA) was documented.

Statistical analysis was performed using SPSS (statistical package for social sciences) ver. 10.
continuous variables were expressed as Mean ± Standard Deviation.

Comparisons between the two groups were performed using independent $t$-test, a $p<0.05$ was considered statistically significant.

**Results**

A total of 60 eyes (50 patients), 30 in the Torsional US group (Group A) and 30 in the conventional linear US group (Group B) were enrolled in the study. The mean age of patients in the Torsional and Conventional Linear groups were 60.5±7.8 years and 61.4±5.4 years respectively. 26 patients were male and 24 were female.

Preoperative BCVA (log MAR) [0.78 in group A and 0.83 in group B] and mean grading of Nuclear hardness showed no difference in both groups.

The differences in Ultrasound Time (UST) and Cumulative Dispersed Energy (CDE) in both groups were statistically significant ($p<0.01$). The mean UST and CDE were lower in the Torsional group than in the Conventional Linear US group. Percent of Mean Total Equivalent Time in Position 3 (USTEPiP3), Mean Balanced Salt Solution (Estimated Fluid Used), Mean Aspiration Time were lower in group A than Group B. Table (2) & Chart (1) illustrate the different parameters in the two groups.

**Table (2): Intraoperative parameters in both groups.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group A</th>
<th>Group B</th>
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<tbody>
<tr>
<td>Mean Total US time</td>
<td>88.6±3.09 sec</td>
<td>115.4±5.4 sec</td>
</tr>
<tr>
<td>Percent of Mean Total Equivalent Time in Position 3</td>
<td>12.1±0.3%</td>
<td>17.3±0.5%</td>
</tr>
<tr>
<td>Mean BSS (Estimated Fluid used)</td>
<td>83.6±2.11 cc</td>
<td>101.5±6.23 cc</td>
</tr>
<tr>
<td>Mean Aspiration Time</td>
<td>4.47±0.1</td>
<td>10.5±0.6</td>
</tr>
<tr>
<td>Mean CDE</td>
<td>19.13±1.2</td>
<td>32.36±3.45</td>
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**Intraoperative complications:**

In group A there were 2 cases of posterior capsular rupture, while 3 cases were encountered in group B. Torsional phaco was more easy in performance than Conventional Linear phaco as there were no repulsion of nuclear material away from phaco tip as in Conventional Linear phaco. No postoperative complications such as fibrin formation, synechia, macrophages on the IOL optic, or endophthalmitis were observed in any patient. Early Postoperative mild corneal edema were more obvious in the Conventional Linear group than the Torsional group, and last for 3 days only. Best-Corrected Visual Acuities (Logarithm of the Minimum Angle of Resolution [log MAR]) after one week were significantly better than preoperative BCVA (log MAR) (Table 3).

**Table (3): Mean pre & postoperative BCVA.**

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<th>Group A</th>
<th>Group B</th>
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<tr>
<td>Mean Preoperative BCVA (log MAR)</td>
<td>0.78±0.09</td>
<td>0.83±0.11</td>
</tr>
<tr>
<td>Mean Postoperative BCVA (one week) (log MAR)</td>
<td>0.15±0.13</td>
<td>0.23±0.05</td>
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Postoperative anterior chamber reactions, and corneal edema which obscure iris details, were not observed in either group.

**Discussion**

Recent developments in phacoemulsification have made cataract removal safer and more efficient. Technological advances have provided more options, allowing surgeons to customize their techniques, to reduce phaco energy and duration. However, phaco energy is still the main risk factor for surgical induced trauma, especially for corneal endothelial cell injury or dysfunction. Phacoemulsification advances aim to reduce the phaco energy and shorten the phaco time Mean Aspiration Time [9,10].

In traditional phaco, the longitudinal movement of the phaco tip tends to push the nuclear parts away with each forward stroke, so the ultrasound has to be purposely interrupted to retract the nuclear fragment to the tip; furthermore, only the forward stroke has cutting effect. While in Torsional phaco, although the tip moves at a lower frequency of 32kHz than the 40kHz in traditional phaco, the side-to-side tip movement sheers the lens material with no repellent force, and cuts with both direction of the tip movement, thus significantly improving emulsify efficiency [1,2,3]. However, there have been debates about the comparative efficacy and
safety of Torsional mode US in hard nucleus cataracts, as compared to longitudinal mode [9].

Considering the frequency of Torsional (32kHz) and conventional linear (40kHz) mode and cutting pattern (Torsional mode cuts both sides, while conventional linear mode cuts forward unidirection), the CDE in Torsional phacoemulsification would theoretically be 40% of the value in conventional linear phacoemulsification, based on the same phaco time. CDE correlates to the total amount of energy at the incision. CDE is calculated as follows for Phaco: CDE = average U/S power x U/S time. In Torsional mode, the CDE was calculated as: Torsional amplitude x Torsional time x 0.4. The frequency of the phaco tip in Torsional mode was 80% of the standard phaco (32kHz in Torsional versus 40kHz in Phaco), and the travel distance of phaco tip in Torsional mode was half that in standard phaco. This helped justify setting the coefficient to 0.4. The UST and CDE values in Torsional and Phaco mode were automatically calculated and displayed on the monitor of the phaco system [8].

Ozil Torsional Technology provides the flexibility of being used alone or in combination with different levels of standard high-frequency Ultrasound energy for different lens densities. Torsional Amplitude can also be set at Fixed Amplitude with no US. The Fixed Amplitude setting and lineal setting are easily interchangeable on the touch screen. Less frictional movements within the incision and lower frequency used in Torsional modality reduced the risk for thermal injury, thus making it safe even with 100% fixed amplitude. In our study in which no cases of incisional burn were found. While in conventional mode, the risks of incisional burn increased with the level of phaco power applied [11].

The main purpose of this study was to evaluate the efficiency of Torsional phaco in handling hard nuclei, comparing with conventional linear phaco. Torsional amplitude was fixed at 100%, which means that the Torsional amplitude reached 100% once the pedal was in the third position 3. Also, the vacuum was set at 350mm Hg and aspiration rate at 35cm^3/min. The advantage of using a higher vacuum and aspiration rate, a technique known as ultrasound-assisted phacoaspiration, makes the whole surgical process less invasive, reducing surgical time and energy [12]. An appropriate phaco tip is another important factor influencing efficient emulsification. In our study, a 0.9mm Micro Tip ABS phaco tip (45°, Kelman) with Micro smooth High Infusion Sleeve was used, although the 0.9mm Tapered ABS phaco tip (45°, Kelman) is recommended for the soft nucleus because it holds the fragment better than the MicroTip ABS. In the case of a hard nucleus, it is easily occluded by the nucleus fragments and needs to be manually rinsed [13,14].

Intraoperative parameters of UST and CDE were compared between both groups. There was a significant difference in UST among both groups, with the longest UST in the conventional linear US group. And as for CDE, it was significantly higher in the conventional linear US group than the Torsional group. These data suggested that conventional linear modality was more time and energy-consuming [8].

Since all surgeries were performed by the same surgeon using the same techniques and settings, variations due to surgical techniques were minimized.

In previous reports, the Torsional phacoemulsification provided a lower level of US time and energy, and more effective phacoemulsification than the conventional methods [3,4]. In the study done by Bozkurt et al., which included 2 groups, conventional linear versus Torsional US, they found that the average UST and CDE were not statistically different between the conventional and the Torsional phaco groups, but the average total equivalent ultrasound power in position 3 (USTEPiP3) in the OZil group was found to be significantly lower than that in the conventional linear phaco group [15]. Also, in a study done by Reuschel et al., there were statistically significant differences in Mean US time, CDE, and % USTEPiP3 between the Torsional group and the longitudinal group [16]. It has been demonstrated that CDE and endothelial cell loss in Torsional mode were lower than those with conventional mode in cataracts of all NO grades [3]. Also, a superior efficiency and safety of Torsional phacoemulsification was demonstrated in hard nucleus samples [4]. Recently, many authors have suggested a better efficiency by the combined Torsional mode and longitudinal mode.

Our study presented a significantly lower CDE, less BSS plus volumes used, and lower phaco time in Torsional mode for hard cataracts, less corneal edema during the early postoperative period, with no difference observed at one month. The mean BCVA at day one was significantly better in the Torsional group which was attributable to less corneal edema secondary to less UST and CDE. However, at 30 days postoperative, the mean BCVA was nearly the same in both groups with no statistically significant differences.
Conclusion:

We conclude that both US modes are effective in management of grades III and IV cataracts. However, the pure Torsional group uses less US energy and time. However, the final visual outcome was similar for both study groups. This result implies that Torsional phacoemulsification is more efficient and is at least equally safe, as compared to conventional phacoemulsification in hard cataracts Further studies involving the use of an intelligent phaco (IP) option with Torsional mode are recommended, as it might have the same efficiency without the repulsion effect of longitudinal US when combined with the Torsional US mode.

References