ABSTRACT:

Purpose: To assess the steps involving generation of maximum energy during torsional phacoemulsification

Methods: 50 patients were randomized into four groups depending on their grade of nuclear sclerosis and subject to torsional phacoemulsification. The surgical procedures were recorded and the videos were analysed in segments depending on the steps of the phaco procedure. The energy expended during the steps were tabulated.

Results: The cumulative dissipated energy with a high correlation to the grade of cataract had maximum rise during the initial procedure of burrowing and segmentation of the nucleus. The energy expended during emulsification of the segments was comparable in all grades.

Conclusions: The energy expended in the system is most during disassembly of the nucleus. Efficient disassembly can thus lead to less energy generation.

INTRODUCTION

The energy produced in a closed system has the potential to produce undesirable effects which translate to damage to corneal endothelial cells, angle structures, iris, and posterior capsule inside the eye. Though with the advent of non-longitudinal modes of phacoemulsification like oscill and ellips, the efficacy of phaco has increased, the parameters on which the dissipated energy depends need to be studied so that factors under the surgeons control can be better understood and therefore modified to produce optimum results.

AIM OF STUDY

Besides the grade of cataract, the technique of dealing with the nucleus of the cataract is likely to have a bearing on the amount of energy used in the system. We decided to study how these factors influence the energy output and how significant that influence is. We also wanted to know the energy expended for each nuclear density and phase of nucleus management in our hands.

Fig. 1 Iris chaffing

Fig. 2. Sectional corneal edema
MATERIALS AND METHODS
This was a prospective randomized trial conducted on 50 patients who had cataract and underwent surgery with the Alcon Infiniti Vision System using Ozil technology. The patients signed an informed consent. The patients were subject to uniform preoperative medications, namely topical antibiotics, NSAIDs and mydriatics. All surgeries were performed by the same surgeon (SN). The incision was a 2.2 mm clear corneal superotemporal one, the position being the surgeon’s preference. Depending on the grade of cataract on a scale of 1 - 4, the machine parameters were adjusted. The initial ozil amplitude varied from 0 with a maximum of 100% in complete footpedal 3 down position. The vacuum was either panel or linear of upto 350 mmHg with a dynamic rise of 2. The aspiration flow rate varied from 30 – 40. A 0.9 miniflared 45 degree Kelman tip with Ultrasleeve (Alcon Lab Inc) was used. The technique of direct chop was used in all patients. The video recording of each case was

Table 1 Average time and energy for different steps of nucleus dissembly

<table>
<thead>
<tr>
<th>Cataract Grade</th>
<th>BurrCde</th>
<th>ChopCde</th>
<th>EmulCde</th>
<th>TotalCde</th>
<th>BurrTime</th>
<th>ChopTime</th>
<th>EmulTime</th>
<th>TotalTime</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.15</td>
<td>0.65</td>
<td>3.57</td>
<td>4.27</td>
<td>3</td>
<td>6.5</td>
<td>46</td>
<td>55.5</td>
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<tr>
<td>2</td>
<td>0.53</td>
<td>0.67</td>
<td>4.25</td>
<td>5.46</td>
<td>5.5</td>
<td>38.25</td>
<td>43.75</td>
<td>87.5</td>
</tr>
<tr>
<td>3</td>
<td>1.81</td>
<td>1.78</td>
<td>11.32</td>
<td>14.88</td>
<td>13</td>
<td>38.33</td>
<td>61.67</td>
<td>108.67</td>
</tr>
<tr>
<td>4</td>
<td>4.99</td>
<td>3.28</td>
<td>18.16</td>
<td>26.43</td>
<td>31</td>
<td>57</td>
<td>127.67</td>
<td>215.67</td>
</tr>
</tbody>
</table>

Fig 3. Gender distribution of patients

Fig 4. Grades of cataract

Fig 5. Energy dissipated during different stages

Fig 6. The rate of energy dissipation during different steps of nucleus dissembly

Fig 7. Overview of metrics, top right corner shows cde at any particular time
studied frame to frame, the metrics and time of burrowing, chopping and emulsification of the nucleus were noted and the values compared for the grade of cataract and the steps of the surgery. This data was analysed using SPSS ver 16.0 software.

RESULTS
29 women and 21 men took part in the study.

There were 12 patients with nuclear sclerosis grades 1 and 4, and 13 with grades 2 and 3 respectively.

The average energy used and time taken to deal with the nucleus of each grade of cataract that was recorded is tabulated depending on the step of nucleus management - burrowing, chopping and emulsification.

The energy dissipated showed an increase from burrowing of the phaco tip, through chop and into emulsification. The time taken was also variable so that on plotting the rate of energy dissipation, it was found that it was comparable during burrowing and emulsification but slowed down during chopping. Eg in grade 4 cataract, it was 0.16 for burrowing and 0.15 for emulsification whereas it decreased to 0.06 for chopping.

In grade 1 cataract alone the energy dissipated for chopping was more compared to the other two steps (0.09 for chop versus 0.05 and 0.07)

DISCUSSION
Torsional ultrasound is more efficacious than longitudinal\textsuperscript{3,5} owing to the additive effect of the shearing forces of the side to side oscillatory motion of the tip and microcavitation in the former, compounded by the absence of chatter or repulsive forces associated with the latter. Of the various parameters that define efficacy in phacoemulsification including the time taken and postoperative indices, the energy dissipated in the system is the most crucial with regard to post operative results. In the torsional mode, this is indicated by the cumulative dissipated energy, which is defined as

\[ \text{CDE} = \text{TOTAL PHACO ENERGY IN FOOT PEDAL POSITION 3} = \text{TORSIONAL TIME} \times \text{AVERAGE TORSIONAL AMPLITUDE} \]

The factor of 0.4 is applied here as torsional energy is reduced owing to two reasons\textsuperscript{3}, the frequency of the phaco tip in torsional mode (32 kHz) being 80\% of that of conventional phaco (40 kHz), and stroke length of the tip in torsional mode (40 microns) being 50\% that in standard mode (80 microns). Reduction in CDE therefore implies generation of less energy and intraoperative factors that it depends on, if known, can help control the adverse effects of lens extraction by torsional ultrasound.

Though the apparatus calculates the total CDE\textsuperscript{4}, we wanted to determine the expenditure of energy in each step of the procedure. The video recordings of these surgeries when analysed frame to frame showed exactly the energy and time taken for a particular step of nucleus management. In this context though the total energy expended for emulsification is more than that for burrowing, so is the time taken for emulsification. To account for this proportional increase in time when we take the rate of energy dissipation into account, they are found to be similar. Chopping, on the other hand, though utilizing energy takes up a lot of time for intermittent nucleus rotation in between chop, prior to digging in the chopper. These interspersed rotatory movements and time taken for the chop separation are hard to separate from the actual burying of the tip using phaco which is the point of energy generation. This artificial increase in time decreases the rate of energy generation during chop which is reflected in the graph.

Direct chop is a refined technique that can be used for nuclei of any hardness, its advantage being the minimal ultrasound used prior to chopping, unlike divide and conquer or stop and chop. Here the only prechop energy required is to create a small burrow in the central nuclear core for the phaco probe to get enough space for a hold to chop. We utilised this technique, not only because it’s a part of our routine procedure but also to use a technique where the prechop energy expenditure is minimum. The prechop and chop energy as a percent of the total CDE for each grade of cataract (table2) shows that 18 to 30\% of the total energy is expended just to break up the nucleus before emulsifying it.

<table>
<thead>
<tr>
<th>Grade of cataract</th>
<th>Burr + Chop CDE</th>
<th>Total CDE</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.8</td>
<td>4.27</td>
<td>18.7</td>
</tr>
<tr>
<td>2</td>
<td>1.2</td>
<td>5.46</td>
<td>22</td>
</tr>
<tr>
<td>3</td>
<td>3.59</td>
<td>14.88</td>
<td>24.1</td>
</tr>
<tr>
<td>4</td>
<td>8.27</td>
<td>26.43</td>
<td>31.3</td>
</tr>
</tbody>
</table>

Table 2. Prechop and chop CDE wrt Total energy

The low CDE averages for even higher degrees of nuclear sclerosis\textsuperscript{1,7} is an evidence of the efficacy of the system, the technique and the kelman tip subject to surgeon experience.

A corollary of this study would be the derivation that any technology that decreases the energy expended during prechop and chop would be reducing a substantial amount of dissipated energy. The use of laser to fragment
the nucleus is one such procedure that is rapidly gaining ground, and this study validates the advantages of using such a technology.

CONCLUSIONS
Torsional phaco is efficacious in cataract surgeries of even higher grades of nuclear sclerosis as evidenced by the cumulative dissipated energy values. Besides the nuclear grade, energy also depends on the stage of nucleus management, the rate of energy consumption being comparative for nuclear fragmentation and emulsification. Technology decreasing energy consumption during nuclear fragmentation would considerably bring down the CDE.

REFERENCES
2. Cesar Espiritu: Ozil IP with grade 4 cataract. CRS today, Oct 2010
5. Oshima Y, Raising the bar; techniques for optimizing phacoemulsification, CRS today, 2011.