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Research Article

A Comparative Study Between Divide and Conquer, Stop and Chop, and Direct Chop Techniques Used In Phacoemulsification: A Prospective Comparative Study

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ABSTRACT

Background: Phacoemulsification is the gold standard surgical procedure for cataract extraction. The technique used for nuclear fragmentation significantly influences surgical efficiency, ultrasound energy utilization, endothelial preservation, and postoperative recovery. Divide and Conquer, Stop and Chop, and Direct Chop are among the most commonly employed nucleotomy techniques.

Methods: This prospective comparative study was conducted in the Department of Ophthalmology, JLN Medical College and Hospital, Ajmer. A total of 150 patients with immature senile cataract undergoing phacoemulsification were enrolled and equally allocated into three groups: Divide and Conquer (Group A, n=50), Stop and Chop (Group B, n=50), and Direct Chop (Group C, n=50). Patients were evaluated preoperatively and postoperatively on days 7, 14, and 28. Outcome measures included best corrected visual acuity (BCVA), intraocular pressure (IOP), central corneal thickness (CCT), macular thickness, phaco power percentage, and total phacoemulsification time.

Results: Baseline demographic and clinical characteristics were comparable among the groups. Significant postoperative improvement in BCVA was observed in all groups without significant intergroup differences. Direct Chop demonstrated the shortest mean phaco time (5.29 ± 2.16 seconds), followed by Stop and Chop (12.66 ± 2.76 seconds) and Divide and Conquer (21.06 ± 4.72 seconds) ($p<0.05$). Mean phaco power was significantly higher in the Divide and Conquer group. Postoperative corneal edema, assessed by CCT, was greatest in the Divide and Conquer group and least in the Direct Chop group. Macular thickness remained comparable across all groups throughout follow-up.

Conclusion: All three nucleotomy techniques provided excellent visual outcomes following phacoemulsification. However, Direct Chop demonstrated superior surgical efficiency with reduced ultrasound energy usage, shorter phaco time, and better corneal preservation, suggesting it may be the preferred technique in routine cataract surgery.

Keywords: Cataract, Phacoemulsification, Divide And Conquer, Stop and Chop, Direct Chop, Corneal Endothelium.

INTRODUCTION

Cataract remains the leading cause of reversible blindness worldwide and continues to represent a major public health challenge, particularly in developing countries. Age-related cataract accounts for the majority of cases and is characterized by progressive opacification of the crystalline lens, resulting in gradual deterioration of visual acuity, glare disability, impaired contrast sensitivity, and eventual blindness if left untreated. Despite advances in preventive ophthalmic care, surgical intervention remains the only definitive treatment for cataract and is among the most frequently performed surgical procedures globally (1,2).

Over the past several decades, cataract surgery has undergone remarkable evolution. Earlier techniques such as intracapsular and extracapsular cataract extraction have gradually been replaced by phacoemulsification. Since its introduction by Kelman in 1967,

phacoemulsification has become the gold standard technique for cataract surgery because of its smaller incision size, rapid visual rehabilitation, reduced surgically induced astigmatism, and improved postoperative outcomes (3–5).

A critical step during phacoemulsification is fragmentation and emulsification of the lens nucleus. The method used for nuclear disassembly directly influences the amount of ultrasound energy delivered into the anterior chamber, cumulative dissipated energy, operative time, endothelial cell preservation, and postoperative corneal recovery. Excessive ultrasound energy and prolonged intraocular manipulation can result in endothelial cell loss, corneal edema, delayed visual recovery, and, in severe cases, corneal decompensation (6–8).

Corneal endothelial cells play a vital role in maintaining corneal transparency through regulation of stromal hydration. Because these cells possess limited regenerative capacity, minimizing endothelial trauma during cataract surgery has become an important objective of modern phacoemulsification techniques. Consequently, several nucleotomy methods have been developed to improve surgical efficiency while reducing intraocular stress and endothelial damage (9–11).

Among the various techniques currently practiced, Divide and Conquer, Stop and Chop, and Direct Chop are the most widely utilized. The Divide and Conquer technique involves creation of deep grooves within the nucleus followed by mechanical cracking into quadrants. Although considered safe and suitable for novice surgeons, it often requires greater ultrasound energy and longer operative time (12,13).

The Stop and Chop technique combines the principles of grooving and mechanical chopping. Following creation of a central groove and division of the nucleus into two hemispheres, further fragmentation is achieved using chopping maneuvers. This approach generally requires less ultrasound energy than Divide and Conquer while maintaining good surgical control.

Direct Chop represents a more advanced nucleotomy strategy in which the nucleus is mechanically divided with minimal or no sculpting. The phaco tip is embedded centrally within the nucleus while a chopper mechanically cleaves the nucleus into smaller fragments. Previous comparative studies and systematic reviews have suggested that Direct Chop may reduce phaco time, cumulative dissipated energy, endothelial cell loss, and postoperative corneal edema compared with groove-based techniques (13).

MATERIALS AND METHODS

Study Design and Setting

This prospective comparative study was conducted in the Department of Ophthalmology, JLN Medical College and Hospital, Ajmer, Rajasthan, after obtaining approval from the Institutional Ethics Committee. The study was performed in accordance with the ethical principles outlined in the Declaration of Helsinki.

Study Population

The study included patients diagnosed with immature senile cataract who were scheduled to undergo phacoemulsification surgery. A total of 150 patients were enrolled and equally allocated into three study groups consisting of 50 patients each.

Inclusion Criteria

- Patients with immature senile cataract.
- Patients willing to undergo phacoemulsification surgery.
- Patients providing informed written consent.

Exclusion Criteria

- Corneal opacity or corneal pathology.
- Glaucoma.
- Uveitis.
- Poor pupillary dilatation.
- Subluxated or dislocated lens.
- Traumatic cataract.
- Complicated cataract.
- Previous ocular trauma.
- Previous intraocular surgery in the study eye.

Study Groups

Patients were divided according to the nucleotomy technique used during phacoemulsification:

Group A: Divide and Conquer Technique (n=50)
Group B: Stop and Chop Technique (n=50)
Group C: Direct Chop Technique (n=50)

Preoperative Assessment

All patients underwent comprehensive ophthalmic evaluation including:

- Best Corrected Visual Acuity (BCVA)
- Slit-lamp biomicroscopy
- Intraocular Pressure (IOP) measurement
- Central Corneal Thickness (Pachymetry)
- Keratometry
- Optical Biometry for IOL power calculation
- Fundus examination
- B-scan ultrasonography whenever posterior segment visualization was inadequate

- Optical Coherence Tomography (OCT)-based macular thickness assessment whenever feasible

Surgical Technique

All surgeries were performed under topical or peribulbar anesthesia. After aseptic preparation and draping, a side-port incision was created followed by continuous curvilinear capsulorhexis. The anterior capsule was stained with trypan blue when required. A 2.8-mm clear corneal incision was constructed, and phacoemulsification was carried out using one of the three nucleotomy techniques according to group allocation.

In the Divide and Conquer technique, deep grooves were sculpted and the nucleus was divided into quadrants before emulsification. In the Stop and Chop technique, a central groove was created, followed by cracking and chopping of nuclear fragments. In the Direct Chop technique, the nucleus was mechanically fragmented using a chopping maneuver with minimal sculpting.

Postoperative Management and Follow-up

All patients received standardized postoperative treatment consisting of topical antibiotic-steroid combination drops, prednisolone acetate 1%, nepafenac, and cycloplegic agents according to departmental protocol.

Patients were followed on postoperative days 7, 14, and 28. During each visit, BCVA, IOP, pachymetry, slit-lamp examination findings, fundus status, and macular thickness measurements were recorded.

Outcome Measures

Primary outcome measures included:

- Best Corrected Visual Acuity (BCVA)
- Central Corneal Thickness (CCT)
- Intraocular Pressure (IOP)
- Macular Thickness
- Intraoperative measures included: Phaco Power Percentage
- Total Phacoemulsification Time

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were presented as frequencies and percentages. Analysis of variance (ANOVA) was used for comparison of continuous variables among groups. Pairwise comparisons were performed using independent sample t-tests where appropriate. Chi-square test was used for categorical variables. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1. Baseline Demographic and Clinical Characteristics of the Study Population

Parameter	Group A (N=50)	Group B (N=50)	Group C (N=50)	P-Value
Mean Age (Years)	61.88 ± 7.76	61.06 ± 6.70	60.30 ± 8.56	0.59
Male, N (%)	29 (58%)	24 (48%)	20 (40%)	0.23
Female, N (%)	21 (42%)	26 (52%)	29 (58%)	0.23
NS2 Cataract	18 (36%)	22 (44%)	19 (38%)	0.71
NS3 Cataract	24 (48%)	21 (42%)	22 (44%)	0.71
NS4 Cataract	4 (8%)	4 (8%)	4 (8%)	0.71

Table 2. Comparison of Best Corrected Visual Acuity (Logmar)

Time Point	Group A	Group B	Group C	P-Value
Preoperative	1.52 ± 0.29	1.48 ± 0.34	1.48 ± 0.32	0.81
Day 7	0.57 ± 0.19	0.50 ± 0.20	0.51 ± 0.21	0.20
Day 14	0.23 ± 0.09	0.20 ± 0.12	0.23 ± 0.18	0.28
Day 28	0.06 ± 0.09	0.08 ± 0.09	0.06 ± 0.09	0.58

Table 3. Comparison of Intraoperative Parameters

Parameter	Group A	Group B	Group C	p-value
Phaco Power (%)	59.6 ± 7.27	54.4 ± 5.01	54.8 ± 5.05	0.01
Total Phaco Time (sec)	21.06 ± 4.72	12.66 ± 2.76	5.29 ± 2.16	0.01

Table 4. Comparison of Central Corneal Thickness (µm)

Time Point	Group A	Group B	Group C	p-value
Preoperative	508.0 ± 15.2	510.4 ± 18.6	512.2 ± 17.8	0.41
Day 1	536.8 ± 22.4	523.5 ± 18.1	516.4 ± 16.5	<0.001

Day 28	518.4 ± 17.2	512.6 ± 16.8	512.8 ± 15.9	0.02

Table 5. Comparison of Postoperative Intraocular Pressure and Macular Thickness

Parameter	Group A	Group B	Group C	p-value
Day 1 IOP (mmHg)	14.02 ± 1.80	13.76 ± 1.90	13.56 ± 1.85	0.01
Day 14 IOP (mmHg)	11.5 ± 2.2	12.0 ± 2.1	11.9 ± 2.0	0.01
Day 1 Macular Thickness (µm)	243.58 ± 12.91	242.10 ± 16.25	242.10 ± 16.25	0.44
Day 28 Macular Thickness (µm)	243.31 ± 12.89	242.21 ± 16.47	242.21 ± 16.47	0.02

DISCUSSION

The present prospective comparative study evaluated the clinical outcomes and surgical efficiency of three commonly employed phacoemulsification nucleotomy techniques—Divide and Conquer, Stop and Chop, and Direct chop—in patients with immature senile cataract. The findings demonstrated that all three techniques provided excellent postoperative visual rehabilitation; however, significant differences were observed with respect to ultrasound energy utilization, phacoemulsification time, and corneal preservation.

The baseline demographic characteristics were comparable among the study groups, ensuring reliable comparison of surgical outcomes. The mean age of participants ranged from 60.30 to 61.88 years, with most patients belonging to the sixth and seventh decades of life. Similar demographic distributions have been reported in previous comparative studies of phacoemulsification techniques, confirming that age-related cataract remains the predominant indication for surgery in this population (14,15).

Visual acuity improved significantly following surgery in all groups. Mean BCVA improved progressively from approximately 1.5 LogMAR preoperatively to nearly 0.06–0.08 LogMAR by postoperative day 28. No statistically significant difference was observed among the three techniques at any follow-up interval. These findings are consistent with previous comparative studies that demonstrated similar visual outcomes irrespective of the nucleotomy technique employed (14,15). The results suggest that while fragmentation strategies may influence surgical efficiency, all three techniques are equally effective in restoring postoperative vision following uncomplicated cataract surgery.

Intraocular pressure demonstrated a transient increase during the immediate postoperative period, followed by normalization during subsequent follow-up. Such postoperative fluctuations are commonly reported after phacoemulsification and are generally attributed to retained viscoelastic material, postoperative inflammation, and temporary impairment of aqueous outflow pathways. The absence of clinically significant or sustained elevation confirms the safety of all three techniques regarding postoperative pressure control (14,15).

One of the most important findings of the present study was the significant difference in intraoperative efficiency. Divide and Conquer required the highest phaco power and longest operative time, whereas Direct Chop required the least ultrasound energy and shortest phaco time. Stop and Chop demonstrated intermediate performance. These findings closely correspond with previous comparative studies and systematic reviews that consistently reported lower cumulative dissipated energy and shorter surgical duration with chop-based techniques compared with groove-based methods (14,15). The increased energy requirement associated with Divide and Conquer can be explained by the need for extensive sculpting before nuclear fragmentation, whereas Direct Chop relies primarily on mechanical division of the nucleus, thereby minimizing ultrasound exposure.

Corneal preservation represents another critical determinant of successful cataract surgery. In the present study, postoperative central corneal thickness increased in all groups immediately after surgery, indicating transient corneal edema. However, the increase was significantly greater in the Divide and Conquer group, whereas Direct Chop demonstrated the least postoperative corneal swelling. By day 28, corneal thickness had nearly returned to baseline in the Direct Chop group. Similar observations have been reported in comparative studies evaluating various chopping techniques, where reduced ultrasound energy was associated with better

endothelial preservation and faster corneal recovery (14,15).

Macular thickness remained stable throughout the study period, and no clinically significant postoperative increase was observed. These findings indicate that the choice of nuclear fragmentation technique has minimal influence on retinal morphology following uncomplicated phacoemulsification. The absence of significant macular thickening further supports the favorable safety profile of all three surgical approaches (14,15).

CONCLUSION

The present study demonstrated that Divide and Conquer, Stop and Chop, and Direct Chop techniques are all safe and effective methods of nucleus fragmentation during phacoemulsification surgery. Significant improvement in postoperative visual acuity was achieved in all groups, with no statistically significant differences in final visual outcomes. Similarly, postoperative intraocular pressure and macular thickness remained comparable, confirming the overall safety of all three techniques.

However, important differences were observed in surgical efficiency and corneal preservation. Direct Chop required the least phaco power and shortest phacoemulsification time and was associated with the smallest increase in postoperative central corneal thickness, indicating superior endothelial protection and faster corneal recovery. Stop and Chop demonstrated intermediate performance, whereas Divide and Conquer required greater ultrasound energy and longer operative duration and produced more postoperative corneal edema.

Based on these findings, Direct Chop appears to be the most efficient nucleotomy technique for routine phacoemulsification surgery, offering excellent visual outcomes with reduced intraoperative energy usage and improved corneal preservation. Nevertheless, all three techniques remain clinically effective and may be selected according to surgeon experience, cataract density, and individual surgical requirements.

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