Results of Coaxial Phacoemulsification Through a 1.8-mm Microincision in Hard Cataracts

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**BACKGROUND AND OBJECTIVE:** To assess the results of coaxial phacoemulsification through 1.8-mm coaxial microincision cataract surgery (C-MICS) phacoemulsification with foldable intraocular lens implantation in eyes with hard cataracts in comparison to eyes with soft cataracts.

**PATIENTS AND METHODS:** Group 1 consisted of 40 eyes of 40 patients with hard cataracts (grade ≥ 4, Lens Opacities Classification System III scale) and group 2 consisted of 45 eyes of 45 patients with non-mature cataracts (grade ≤ 2, Lens Opacities Classification System III scale). All surgeries were performed by two experienced surgeons under topical and intracameral anesthesia. Examinations were performed preoperatively and 1 month after the surgery. Examined parameters included distance-corrected visual acuity (DCVA), autorefractometry, keratometry, tonometry, endothelial cell counts, and biomicroscopy of the anterior and posterior segment. Surgically induced astigmatism was calculated with vector analysis.

**RESULTS:** Mean DCVA was 0.16 ± 0.16 preoperatively and 0.92 ± 0.21 postoperatively in group 1 ($P < .05$) and 0.62 ± 0.18 preoperatively and 0.97 ± 0.08 postoperatively in group 2 ($P < .05$). Mean surgically induced astigmatism was 0.48 ± 0.44 in group 1 and 0.53 ± 0.38 in group 2 ($P > .05$). Mean endothelial cell loss was 11.37% ± 12.87% in group 1 and 2.87% ± 9.66% in group 2 ($P < .05$).

**CONCLUSION:** Although density of cataract has an unfavorable influence on early postoperative corneal endothelial cell loss, it did not significantly influence final DCVA and surgically induced astigmatism. C-MICS is a safe and effective method of treatment of cataracts, including cataracts with hard nuclei, and usually leads to good functional outcomes.

INTRODUCTION

The techniques used for cataract surgery are constantly being refined and improved. Microincisions, defined by Alio et al.1,2 as incisions of smaller than 2 mm in width, are an important step in this development.

Recently, two types of phacoemulsification using microincisions have been introduced: coaxial microincision cataract surgery (C-MICS) and bimanual microincision cataract surgery (B-MICS). It is thought that the main advantage of the C-MICS technique is its similarity to standard phacoemulsification.3

When cataract develops, the water-insoluble protein concentration increases and the lens nucleus becomes harder.4 Advanced stages of cataract are now seen infrequently; however, they are still encountered, especially in developing countries. In cases with hard nuclei, surgery is particularly challenging because the risk of complications is higher. Nevertheless, if the surgery is performed with adequate care, achieving good postoperative visual acuity is possible.5-7

The purpose of this study was to evaluate the results of C-MICS with foldable Akreos MI60 Bausch & Lomb intraocular lens (IOL) implantation (Bausch & Lomb, Rochester, NY) through a 1.8-mm temporal clear corneal microincision in eyes with hard cataracts in comparison to eyes with non-mature soft cataracts.

PATIENTS AND METHODS

The study was based on a non-randomized, prospective, consecutive series of patients. Patients who had undergone any previous intraocular surgery and had a history of ocular trauma or inflammation, as well as patients with pseudoexfoliation syndrome, corneal disorders, patients with preoperative endothelial cell counts of less than 1,500 cells/mm², and patients with brunescent black or white hypermature cataracts were excluded from the study.

The examined group (group 1) included 40 eyes of 40 consecutive patients who underwent C-MICS with a foldable IOL implantation (Akreos MI60) through a 1.8-mm temporal clear corneal microincision. The reference group (group 2) consisted of 45 eyes of 45 consecutive patients who underwent C-MICS with a foldable IOL implantation (Akreos MI60) through a 1.8-mm temporal clear corneal microincision.

Preoperatively, mydriasis was achieved with a solution of tropicamide 1% and phenylephrine (NeoSynephrine; Ursapharm Arzneimittel GMBH, Saarbrücken, Germany) in all patients. All phacoemulsifications were performed using the Stellaris phacoemulsification machine (Bausch & Lomb) by two experienced surgeons (AS and WO) under local, topical proxymetacaine hydrochloride (Alcaine; Alcon Laboratories, Fort Worth, TX) drops and lidocaine 2% gel and intracameral (lidocaine 1% solution) anesthesia.

In all cases, hydroxypropyl methylcellulose 2% (Celoftal; Alcon Laboratories) was used as an ophthalmic viscosurgical device and balanced salt solution was used as the infusion fluid. The same surgical settings (aspiration flow was set at 25 cm³/min and vacuum at 400 mm Hg), type of keratome, burst mode of phacoemulsification, and “stop and chop” technique of dividing the nucleus were used in all patients from both groups.

The same operating technique was used in all patients. First, a self-sealing 1.8-mm wide sutureless clear corneal incision was created temporally with a trapezoidal 1.6- to 1.8-mm keratome (E7600; Bausch & Lomb). Continuous curvilinear capsulorrhexis was performed under viscoelastic with micro-forceps. A 20-gauge microvitreoretinectomy blade was used to create two side ports in the clear cornea 90° away from the main incision for bimanual aspiration and irrigation tips. Phacoemulsification and aspiration were then performed and a single-piece acrylic foldable lens (Akreos MI60) was implanted through the main incision in a wound-assisted manner with an injector (1.8-mm Viscoject; Medicel AG, Wolfhalden, Switzerland).8

The same postoperative regimen of treatment was applied for all patients: topical neomycin-polymyxin B-dexamethasone (Maxitrol; Alcon Laboratories, Fort Worth, TX) eye drops were used four times daily for 3 weeks postoperatively.

Examinations were performed preoperatively and 1 month after the surgery. The examined parameters included distance-corrected visual acuity (DCVA), autorefractometry, keratometry, tonometry, biomicroscopy of the anterior and posterior segment, and presence of complications. Surgical parameters displayed by the phaco machine were recorded after each surgical procedure. The Lens Opacities Classification System III (LOCS III) scale was used to evaluate lens opacities and density.9 Keratometry was performed preoperatively and during the final visit, using Javal’s keratometer in the 3-mm central part of the cornea. Surgically

126
induced astigmatism was calculated with vector analysis method. 18-12

Statistical analysis was performed using parametric tests. Changes of preoperative and postoperative values in the same group were compared using the two-tailed Student’s t test for two paired samples and statistical significance between two groups was determined using the two-tailed Student’s t test for independent samples. All calculations were performed for the significance level α = 0.05 using Microsoft Excel (Microsoft Corporation, Redmond, WA) and XLStat 2008 (Addinsoft, New York, NY) software. A P value of less than .05 was considered statistically significant.

RESULTS

The examined group (group 1) included 40 eyes of 40 consecutive patients: 24 women (60%) and 16 men (40%), ages ranging from 43 to 85 years (mean: 72.65 years; standard deviation: ± 9.34 years). Patients from group 1 had hard cataract (grade nuclear opalescence/nuclear color [NO/NC] ≥ 4) according to the LOCS III scale. 9

The reference group (group 2) consisted of 45 eyes of 45 consecutive patients: 27 women (60%) and 18 men (40%), ages ranging from 36 to 90 years (mean: 71.04 years; standard deviation: ± 11.49 years). Patients from group 2 had non-mature, soft cataract (grade NO/NC ≤ 2) according to the LOCS III scale.

Mean LOCS values were 4.03 ± 0.89 in group 1 and 2.33 ± 0.71 in group 2. There were no serious intraoperative complications observed in any patient from both groups. There were mild intraoperative complications observed in three eyes, but this did not influence final visual acuity.

Preoperative DCVA in group 1 was 0.16 ± 0.16, whereas it amounted to 0.62 ± 0.18 in group 2. The difference in preoperative DCVA in both groups was significant (P < .05). Postoperative DCVA was 0.92 ± 0.21 in group 1 and 0.97 ± 0.08 in group 2. DCVA increased significantly after the surgery in both groups (P < .001; Fig. 1). Functional outcomes were similar in both groups; there was no significant difference in postoperative DCVA between the two groups (P > .05) (Table 1). Nevertheless, we observed a small between-group difference in frequency of full DCVA. Postoperative DCVA equal to 6/6 was present in 72.5% of eyes in group 1 and 86.7% of eyes in group 2.

Operating parameters are shown in Table 2. Both average ultrasound power and effective phaco time were significantly higher in group 1 (P < .05). Values of mean intraocular pressure (IOP) are shown in Table 3. There was no between-group difference in either mean preoperative IOP or postoperative IOP (P > .05).

Values of preoperative and postoperative astigmatism are shown in Table 4. There was no difference in either mean preoperative astigmatism or postoperative astigmatism between the examined groups (P > .05). Figure 2 shows that mean surgically induced astigmatism calculated by vector analysis was small and was similar in both groups (P > .05). We found that mean surgically induced astigmatism was 0.48 ± 0.44 in group 1 and 0.53 ± 0.38 in group 2. This difference was not significant (P > .05).

Mean preoperative endothelial cell density amounted to 2,496.58 ± 368.67 cells/mm² in group 1 and was 2,526.09 ± 386.99 cells/mm² in group 2. There was no difference in preoperative endothelial cell density between the groups (P > .05).
Postoperatively, there was a significant decrease in endothelial cell density in both groups ($P < .05$). Mean postoperative endothelial cell density amounted to 2,220.18 ± 477.13 cells/mm² in group 1 and 2,449.40 ± 413.01 cells/mm² in group 2. The difference in postoperative endothelial cell density between the groups was significant ($P < .05$), with higher cell density in group 2 (Table 5). Moreover, there was a significant increase in postoperative average endothelial cell size in both groups when compared with preoperative values. This increase was significantly higher in group 1 ($P < .05$). There was a loss of 11.37% of corneal endothelial cells in eyes with hard cataracts, whereas this loss was significantly lower in the reference group and amounted to 2.87%. This difference was significant ($P < .05$).

There were no serious postoperative complications present in any patient. We observed mild and mainly transient complications in the early postoperative period, such as Descemet folds and corneal edema (Table 6). There was a small area of iris damage from the phaco tip in one eye from each group and we observed a partial capsular dialysis in one eye from group 1. Descemet folds and corneal edema were present in the early postoperative period in a total of 20% of eyes ($n = 8$) from group 1 and 11% of eyes ($n = 5$) from group 2. Moreover, we observed a temporary IOP increase in the first day after the surgery in one eye from group 1.

### DISCUSSION

Recent decades have brought further evolution of surgical techniques in cataract surgery, which was connected with a decrease of the width of incision, with the primary goal being the reduction of surgical trauma. Modern techniques of phacoemulsification have enabled surgeons to perform cataract surgery safely and
efficiently. Currently, conventional phacoemulsification requires corneal incision between 2.2 and 2.8 mm wide. Alio et al. defined the term microincision cataract surgery as phacoemulsification that is performed through an incision smaller than 2 mm.1,2 Currently, there are two techniques of phacoemulsification that use microincision: B-MICS and C-MICS.

Standard phacoemulsification is known as an excellent technique for removing soft nuclei, but it is also suitable for hard nuclei, mature white, or even brunescent cataracts.6,7,13 Nevertheless, because there have been reports of a much higher rate of complications and a higher corneal endothelial damage caused by excessive ultrasound energy, there are surgeons who prefer to convert to extracapsular cataract extraction in such cases.13-15 In contrast, phacoemulsification is believed to offer an advantage of in-the-bag implantation of the IOL through a small incision and through a continuous capsulorrhesis.13 To date, there have been no reports evaluating safety and effectiveness of C-MICS in cataracts with hard nuclei.

Other studies involving patients after coaxial phacoemulsification confirm our finding that there was no significant difference in postoperative DCVA between the two groups. Ermiss et al.6 examined 82 patients with mature cataracts who had coaxial phacoemulsification through a 3.2-mm clear corneal incision and found that the mean postoperative DCVA, IOP, and the rate of posterior capsular rupture were not significantly different from the reference group and the mean phacoemulsification time and ultrasound power were significantly higher in eyes with mature cataract.

The literature confirms our finding that the mean postoperative endothelial cell density loss in the final visit is significantly higher in eyes with hard nuclei. Wong et al.16 examined 25 eyes with white mature cataracts that underwent B-MICS. In their study, the surgery was uneventful in 24 eyes; however, in 1 eye it was necessary to convert to extracapsular cataract extraction. The authors concluded that there was no difference in mean endothelial cell density 3 months postoperatively in comparison to eyes with non-mature cataracts and did not observe any serious complications in their series of patients. In our group, it was not necessary to convert to standard phacoemulsification or extracapsular cataract extraction in any case. Singh et al.13 examined 123 eyes with brunescent cataracts and found that the mean endothelial cell density loss was approximately 10% after 1 month, which was similar to our group. Walkow et al.17 found that the mean endothelial cell density loss after standard phacoemulsification amounted to 11.9%. Similarly, Vasavada et al.18 examined 60 eyes and observed that the mean endothelial cell density in eyes with mature cataracts amounted to approximately 10% 1 month postoperatively; however, this value increased to as much as 18% 6 months postoperatively.

### Table 5

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group 1</th>
<th>Group 2</th>
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<tbody>
<tr>
<td></td>
<td>Preoperative Mean ± SD</td>
<td>Postoperative Mean ± SD</td>
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<tr>
<td>Average cell size (μm²)</td>
<td>408.38 ± 65.84</td>
<td>476.45 ± 134.24</td>
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<tr>
<td>Enzymatic cell density (cells/mm²)</td>
<td>2,496.58 ± 368.67</td>
<td>2,220.18 ± 477.13</td>
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*SD = standard deviation.*

### Table 6

<table>
<thead>
<tr>
<th>Complication</th>
<th>Group 1 (n = 40)</th>
<th>Group 2 (n = 45)</th>
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<tbody>
<tr>
<td>Descemet folds</td>
<td>6 (15.00)</td>
<td>3 (6.67)</td>
</tr>
<tr>
<td>Transient IOP increase</td>
<td>1 (2.50)</td>
<td>0 (0.00)</td>
</tr>
<tr>
<td>Corneal edema</td>
<td>2 (5.00)</td>
<td>2 (4.44)</td>
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<tr>
<td>Iris damaged by phaco tip</td>
<td>1 (2.50)</td>
<td>1 (2.22)</td>
</tr>
<tr>
<td>Capsular dialysis</td>
<td>1 (2.50)</td>
<td>0 (0.00)</td>
</tr>
<tr>
<td>Complications in total</td>
<td>10 (27.5)</td>
<td>6 (13.3)</td>
</tr>
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*IOP = intraocular pressure.*
Mean effective phacoemulsification time and average ultrasound power were significantly higher in group 1, which confirmed earlier findings of studies evaluating coaxial phacoemulsification. It is known that surgically induced astigmatism is significantly smaller after C-MICS in comparison with standard phacoemulsification. We found that surgically induced astigmatism calculated by vector analysis was small and similar in both groups, which stems from the fact that all eyes from both groups underwent C-MICS. This suggests that, irrespective of nuclear density, the same width and localization of corneal incision during phacoemulsification induces a similar value of surgically induced astigmatism. These results indirectly confirm that there were no corneal wound burns in any case. Nevertheless, there are reports stating that the rate of wound thermal injury in eyes with hard nuclei is higher.

In dense, mature cataracts, visualization is worse because of poor red reflex, the lens capsule is fragile, zonular dialysis and posterior capsule rupture are more likely during manipulations of the dense nucleus, or its fragments and the raised intracapsular pressure may cause the tear to easily extend peripherally. In hard cataracts, the lens fibers are cohesive, making the nucleus fractis and the nuclear rotation difficult. Hard cataracts require longer phaco time and more manipulations to divide the nucleus into small parts. Longer time and higher levels of ultrasounds can lead to corneal endothelial damage and might also induce scleral or corneal burns, thus increasing postoperative surgically induced astigmatism.

Although capsulorrhexis was more difficult in group 1, the red reflex was poor but adequate enough to perform capsulorrhexis in all eyes from both groups without using capsular staining. We managed to achieve one-stage, 5-mm diameter capsulorrhexis in all eyes. We observed neither posterior capsule tear nor vitreous loss in any case. Because the cataracts in group 1 were not hypermature white, we observed no leakage of fluid on puncturing the capsule. Similarly, in other studies pertaining to mature cataracts, the authors also managed to create a one-stage or two-stage capsulorrhexis under an ophthalmic viscosurgical device successfully.

In addition, because the posterior capsule is often thinned and weakened and the epinucleus is often thin or sometimes absent, risk of capsular rupture is increased. To minimize this risk, it is possible to use a chopping technique of nucleus division, to adjust phaco parameters, and to inject an ophthalmic viscosurgical device behind the nucleus to protect the capsule. Moreover, hydrodissection causes an additional risk of capsular rupture because a poor red reflex and poor visibility of the fluid wave makes it easy to use too much fluid during this phase.

Postoperative complications included transient striate keratopathy and corneal edema, which are also the most frequent transient complications of coaxial phacoemulsification of hard nuclei. We observed a transient IOP rise on the first postoperative day in one eye from group 1 that resolved after using topical treatment, whereas in group 2 there were no such cases. In the literature, other intraoperative complications present in mature and hard cataracts are described, such as peripheral extension of capsulorrhexis or incomplete capsulorrhexis, posterior capsule tear, pupillary miosis, iris damage by the phaco tip, thermal injury to the corneal wound, and zonular dialysis. In our study, most of these complications were absent, which may stem from the fact that these complications were described mainly in hypermature or mature white cataracts.

The fact that postoperative complications were not frequent suggests that, despite the difficulties connected with the surgery of hard cataracts, successful surgery is possible with adequate care. Although density of cataract has an unfavorable influence on early postoperative corneal endothelial cell loss, postoperative average cell size, and cell density, it did not significantly influence final DCVA and surgically induced astigmatism.

From the literature, it is known that the MICS technique is an excellent alternative to conventional phacoemulsification and has the advantages of reducing the surgical trauma, high stability of the incision, quick wound healing, and fast visual rehabilitation, as well as inducing smaller values of surgically induced astigmatism.

Our study shows that C-MICS is a safe and effective method of treatment of cataracts with hard nuclei and it usually leads to good functional outcomes. These results encourage the further evolution of cataract surgery connected with a decrease of the surgical incision; however, there should be a similar development in IOL technology that could make it possible to perform almost non-invasive surgery in most cataract cases, including eyes with hard nuclei.
REFERENCES


