Comparison of Nagahara phaco-chop and stop-and-chop phacoemulsification nucleotomy techniques

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Purpose: To compare intraoperative and postoperative effects of Nagahara phaco-chop and stop-and-chop phacoemulsification nucleotomy techniques.

Setting: Department of Ophthalmology, SBMU First Aid and Traumatology Hospital, Ankara, Turkey.

Methods: Seventy patients were evaluated prospectively in 2 groups. The Nagahara phaco-chop nucleotomy technique was performed in Group 1 (35 eyes) and the stop-and-chop technique in Group 2 (35 eyes). There were no significant between-group differences. The mean phaco time, phaco power, effective phaco time, time to achieve maximum vision, corneal thickness increase relative to the preoperative values, and time to return to the preoperative values were determined. All parameters in both groups were statistically compared using the chi-square test and the independent-samples *t* test.

Results: The mean phaco time was 1.3 minutes ± 0.7 (SD), phaco power was 16.7% ± 5.0%, and effective phaco time was 14.9 ± 11.8 seconds in Group 1 and 1.8 ± 0.9 minutes, 20.0% ± 6.2%, and 22.3 ± 14.2 seconds, respectively, in Group 2. The mean time to achieve maximum vision postoperatively was 6.9 ± 3.7 days in Group 1 and 11.7 ± 7.7 days in Group 2. The mean postoperative corneal thickness increase in Group 1 and Group 2 was 52.3 ± 84.5 μm and 111.6 ± 151.2 μm, respectively, and the mean time to return to preoperative pachymetry values, 9.8 ± 5.7 days and 13.7 ± 10.0 days, respectively. There were significant between-group differences in these parameters.

Conclusions: The Nagahara phaco-chop technique had fewer negative effects on the corneal endothelium as less ultrasonic energy was used. This accelerated the functional healing process and the return to preoperative physiologic values.

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Many variations on phacoemulsification techniques have been described.[1] The aim of all the techniques is to reduce the stress on the zonules and decrease the total ultrasound time and ultrasound energy used during nucleus emulsification. A method that protects intraocular tissues, especially the corneal endothelium, from surgical damage and has minimal complications rates is the objective. Among the techniques, stop-and-chop and phaco-chop are the most popular. The nucleus is divided mechanically into small fragments with a special instrument known as a chopper in both techniques. The main difference between the 2 is that at the beginning of the stop-and-chop procedure, ultrasound energy is used to produce a central groove. The cavity, which is produced by using more ultrasound power, helps the surgeon split the hard posterior plate, facilitating the procedure.

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Only a few articles compare the phaco-chop and stop-and chop techniques using several parameters. In this study, we compared the efficiency and safety of the 2 techniques prospectively.

Patients and Methods

This prospective randomized study comprised 70 eyes of 70 patients with cataract who were randomly assigned (by a coin flip) to have phacoemulsification using the Nagahara phaco-chop technique or the stop-and-chop technique. Visual acuity, intraocular pressure, nuclear density, and ultrasound central corneal pachymetry were evaluated preoperatively. Nuclear density was graded by color using slitlamp biomicroscopy: 1 = gray or green–yellow, 2 = yellow, 3 = amber, 4 = brown–black.[2] Exclusion criteria were corneal disease or opacity, glaucoma, uveitis, pupillary dilation problem, and previous ocular trauma or surgery.

Phacoemulsification was performed by the same surgeon (İ.C.), who was experienced in both techniques, with the Series 20000® Legacy® phacoemulsification unit (Alcon Laboratories). In all cases, surgery began with a clear corneal incision made with a 3.0 slit knife at the 9 o'clock meridian in right eyes and the 11 o'clock meridian in left eyes. Two side-port incisions were then made with the 20-gauge MVR knife 90 degrees from the main incision. Following the injection of chondroitin sulfate 4%–sodium hyaluronate 3% (Viscoat®) into the anterior chamber, a capsulorhexis was performed. Hydrodissection was done with a 27-gauge flat cannula, and phacoemulsification was performed. In all cases, a 0.9 mm flared, 30-degree, ABS Kelman microtip was used. The standard parameters used during phacoemulsification to create a groove were memory 1, vacuum 50 mm Hg, aspiration flow rate (AFR) 24 cc/min, phaco power 75%, bottle height 78 cm; and to perform quadrant emulsification, memory 2, vacuum 350 mm Hg, AFR 30 cc/min, phaco power 60%, and bottle height 110 cm.

In Group 1 (Nagahara phaco chop), phacoemulsification began with quadrant-removal parameters (memory 2). After the superficial cortex and epinucleus were aspirated, the phaco tip was buried in the center of the endonucleus with high vacuum with the footpedal (FP) in position 3. While the footpedal was in position 2, the Fine-Nagahara phaco chopper (Rhein Medical) was brought through the side-port incision and the equator of endonucleus was engaged by the chopper under the lower edge of the capsulorhexis and pulled toward the phaco tip. The 2 instruments were then separated laterally to produce a complete fracture of the nucleus (Figure 1). This process continued for both nuclear halves, and then the small fragments were emulsified and aspirated with phaco power.

In Group 2 (stop and chop), phacoemulsification began with groove-forming parameters (memory 1). After a groove that was 90% of the nucleus thickness was created, the nucleus was split with the Rosen chopper (Katena Products, Inc.) (Figure 2). After the nucleus was split, the phacoemulsification unit was set at memory 2 and the nuclear halves were cut into fragments and then emulsified and aspirated as in the phaco-chop group. Epinucleus and cortex removal were performed with bimanual infusion/aspiration (I/A) cannulas (+500 mm Hg vacuum and 25 cc/min AFR) in both groups. After this, sodium hyaluronate 1% (Healon®) was injected into the anterior chamber, the incision was enlarged to 5.5 mm, and an intraocular lens (IOL) (Crystal type-05 made of poly[methyl methacrylate] with a 5.5 mm optic and 12.0 mm overall length [Alcon]) was inserted in the capsular bag. The incision site was closed with a 10-0 monofilament single suture. The ophthalmic viscosurgical device was removed from the anterior chamber by I/A. After the side ports were closed by stromal hydration, the procedure was completed.

All procedures were uneventful. Intraoperative parameters—phaco time (minute), mean phaco power (average power) (%), and effective phaco time (calculated time required if 100% power had been used throughout)—were recorded. The effective phaco time was calculated with the following formula: phaco time (seconds) × mean phaco power (average power)/100.

The best corrected visual acuity, time to achieve best visual acuity, pachymetry, corneal thickness increase according to the preoperative values, and time to return to the preoperative values (±20 μm of the preoperative value) were recorded postoperatively. Patients were examined daily in the first week, at an interval of 2 or 3 days in the first month, and then every month. Two of us (T.T., M.Ö.) were masked to the randomization while performing the postoperative examinations.

The chi-square test and the independent-samples *t* test were used to compare the groups for statistical significance. All tests were 2-sided, and *P* values of 0.05 or less were considered statistically significant.

Results

Seventy patients were evaluated in 2 groups of 35 each. The characteristics of the patients in both groups are shown in Table 1. There was no statistically significant between-group difference in any characteristic.

All between-group differences in intraoperative and postoperative parameters except mean postoperative visual acuity were significant (Table 2). The results show that the postoperative healing period was shorter in the phaco-chop group.

Discussion

Nagahara introduced the phaco-chop technique concept in 1993 (K. Nagahara, MD, "Phaco Chop," presented as a video at the ASCRS Symposium on Cataract, IOL and Refractive Surgery, Seattle, Washing-

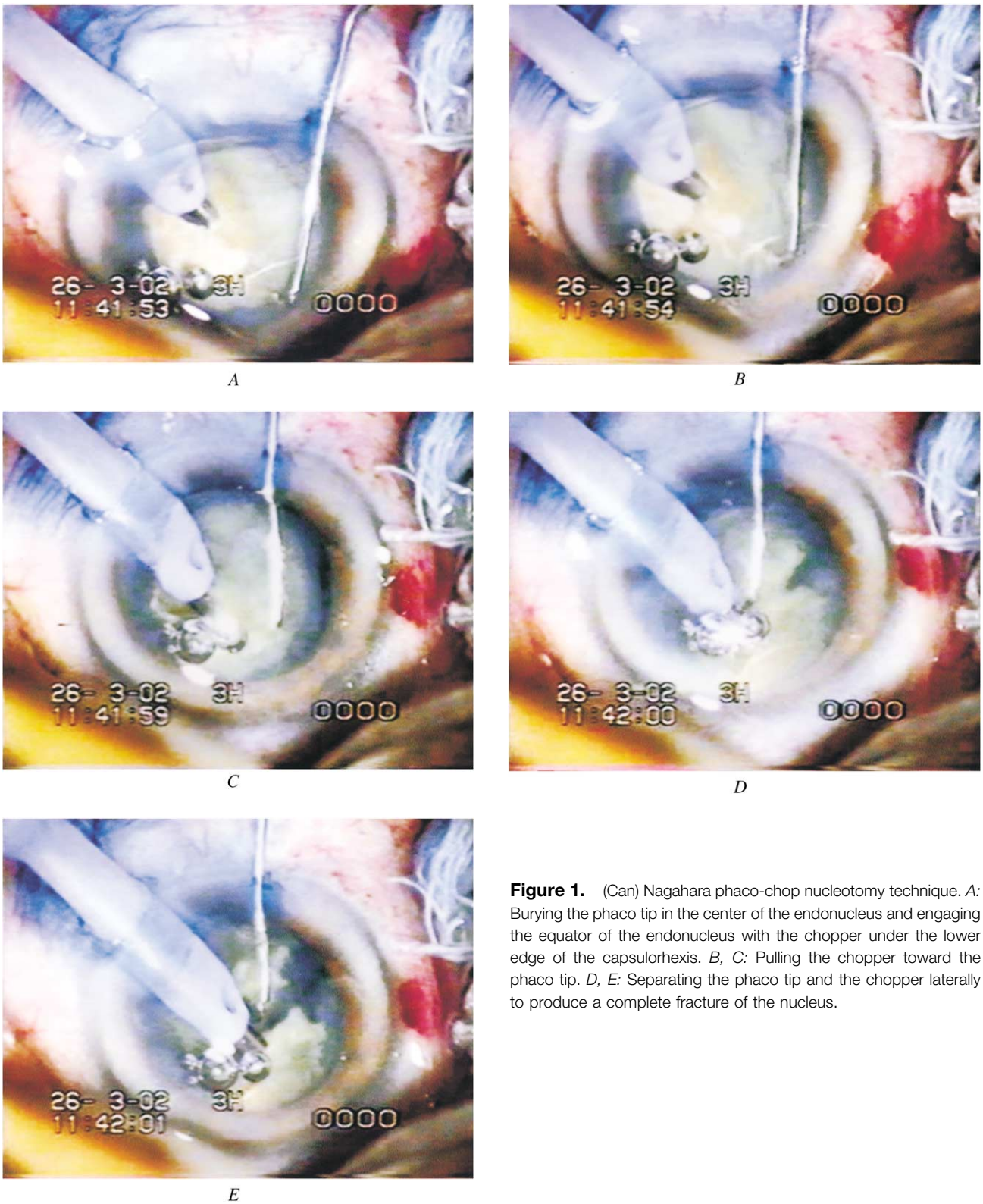

Figure 1. (Can) Nagahara phaco-chop nucleotomy technique. *A:* Burying the phaco tip in the center of the endonucleus and engaging the equator of the endonucleus with the chopper under the lower edge of the capsulorhexis. *B, C:* Pulling the chopper toward the phaco tip. *D, E:* Separating the phaco tip and the chopper laterally to produce a complete fracture of the nucleus.

ton, USA, May 1993; "Phaco-Chop Technique Eliminates Central Sculpting and Allows Faster, Safer Phaco," Ocular Surgery News, international edition, October 1993, pages 12–13). The phaco-chop procedure is a nucleus-separation process, which is performed in the natural cleavage planes of the lens. The human lens

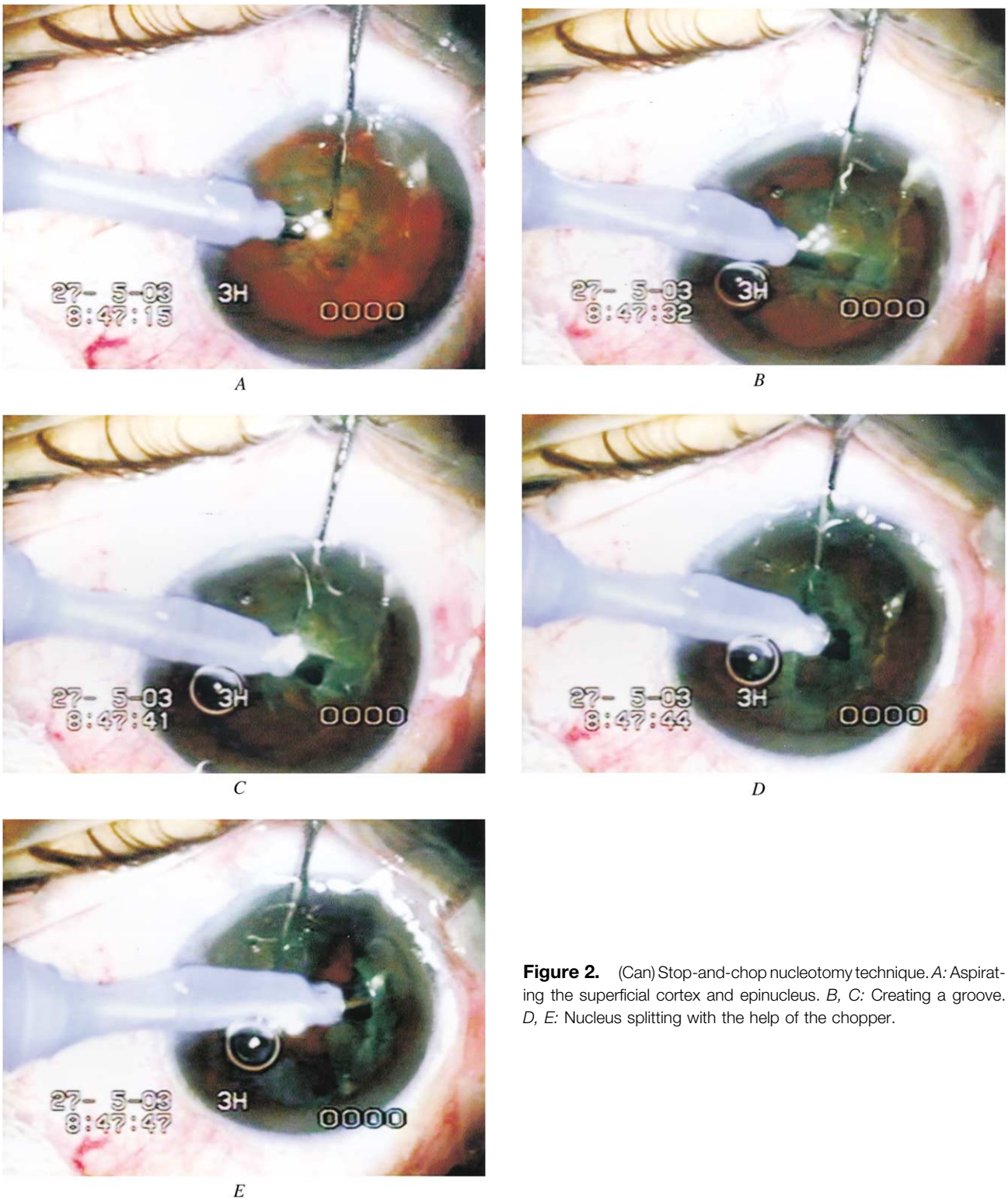

Figure 2. (Can) Stop-and-chop nucleotomy technique. *A:* Aspirating the superficial cortex and epinucleus. *B, C:* Creating a groove. *D, E:* Nucleus splitting with the help of the chopper.

fibers are arranged as parallel lamellae, oriented much like the grain in a piece of wood. A natural cleavage plane occurs when the chopping forces are parallel to these lamellae. Nucleus separation is performed after the nucleus is pressed between the chopper and the phaco tip and the chopper is pulled toward the phaco tip.

The stop-and-chop technique introduced by Koch[3] begins by creating a central groove, which provides space and facilitates separation of the posterior plate.

Table 1. Patients' characteristics.

Characteristic	Group 1 (Phaco Chop) (n = 35)	Group 2 (Stop and Chop) (n = 35)	*P* Value
Age (y)	68.6 ± 10.5	70.2 ± 8.8	.477*
Sex (male/female)	14/21	13/22	.806†
Right eye/left eye	18/17	15/20	.473†
Preoperative visual acuity	0.21 ± 0.22	0.25 ± 0.21	.481*
Follow-up period (d)	298.7 ± 91.5	317.4 ± 93.5	.401*
Nuclear density	2.6 ± 0.9	2.4 ± 0.8	.371*
Preoperative corneal thickness (μm)	534.7 ± 57.2	540.1 ± 35.4	.637*

Means ± SD
*Independent-samples *t* test
†Chi-square test

After this, the cracking procedure is stopped and chopping of the remaining parts begins. The creation of a central groove at the beginning of the procedure is the main difference between phaco chop and stop and chop. During the creation of the groove, the cutting process is directed perpendicular to the lens lamellae, which resembles sawing through a log lying on its side. It requires multiple back-and-forth passes. In the phaco-chop procedure, a process that resembles chopping an upright log with an axe is performed. One strike, parallel to the grain, splits the log in half. Less phaco power and phaco time are needed, and stress on the zonules is minimized.[4]

A force to hold the nucleus, similar to a vise holding a piece of wood, is needed while the nucleus is separated. This force is the zonules and lens capsule in the stop-and-chop technique and the phaco tip buried in the nucleus in the phaco-chop technique. Centrifugal movements in the phaco-chop technique is farther from the zonules, whereas creating the groove in the stop-and-chop technique increases the stress on the zonules with movement toward them. As a result, the nucleus-separation process is done manually instead of by ultrasound energy as in the phaco-chop technique, which results in less damage to intraocular tissues.

Phacoemulsification has additional potential risks for corneal endothelial cell damage related with to ultrasound compared with extracapsular cataract extraction.[5–8] These factors are mechanical (damage caused by turbulence); air bubble; release of free radicals; greater irrigation fluid volume; and direct trauma from surgical instruments, lens fragments, and the IOL.[9–14] Hayashi and coauthors[15] defined advanced age, small pupils, hard and large nucleus, greater infusion volume, and greater total

Table 2. Intraoperative and postoperative parameters in the 2 groups.

Parameter	Group 1 (Phaco Chop) (n = 35)	Group 2 (Stop and Chop) (n = 35)	*P* Value*
Phaco time (min)	1.3 ± 0.7	1.8 ± 0.9	.027
Phaco power (%)	18.7 ± 5.0	20.0 ± 6.2	.017
Effective phaco time (s)	14.9 ± 11.8	22.3 ± 14.2	.021
Postoperative visual acuity	0.79 ± 0.33	0.81 ± 0.24	.703
Time to achieve BCVA (d)	6.9 ± 3.7	11.7 ± 7.7	.002
Increase in CT (μm)	52.3 ± 84.5	111.6 ± 151.2	.048
Time to return to preoperative CT (d)	9.8 ± 5.7	13.7 ± 10.0	.047

Means ± SD
BCVA = best corrected visual acuity; CT = corneal thickness
*Independent-samples *t* test

ultrasound energy as the main risk factors for corneal endothelial damage during phacoemulsification. It is important to shorten the phaco time and reduce the phaco power to protect the corneal endothelium in phacoemulsification. We compared 2 techniques according to these parameters in this study. Our results showed that phaco time, phaco power, and effective phaco time were significantly lower in the phaco-chop group. In the postoperative follow-up period, corneal edema was significantly lower and the healing period (time to achieve best corrected visual acuity and time to return to the preoperative pachymetry values) was also shorter in this group.

Studies comparing the 2 techniques are rare. In a study by Vajpayee et al.,[16] with 20 patients in each group, there were no significant differences between the phaco-chop and stop-and-chop groups in effective phaco time and endothelial loss; there were no data showing rehabilitation time. In a study of the divide-and-conquer and phaco-chop techniques by Wong and coauthors,[17] there were significant between-group differences in phaco time and power in favor of the phaco-chop group. The authors stated there was no difference in complications, but there were no data showing with which technique visual rehabilitation was faster.

The corneal endothelial cell density and irrigation fluid volume used during surgery should be measured and the number of patients increased to have more specific results in our study. Since no complication was seen during the procedures, the results showed the negative effects of phaco time and power and also showed that these parameters affect the healing time directly. Phaco-chop technique was superior to the stop-and-chop technique as it decreased the phaco parameters and shortened the postoperative healing period.

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