ARTICLE

Evaluating the safety and operability of asymmetric trapezoid and near-square side-port incision in cataract surgery

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Purpose: To compare the accuracy, safety, and consistency of asymmetric trapezoid and near-square side-port incision in cataract surgery.

Setting: Aier Eye Hospital of Wuhan University, Wuhan, Hubei Province, China.

Design: Prospective pilot study.

Methods: This study included patients who underwent phacoemulsification between January 2022 and August 2022. They were divided into Group A and Group B using the random number table method. Group A was given a near-square side-port incision and Group B was given an asymmetric trapezoid side-port incision. We contrasted the differences in incision length, width, and shape; surgical time; and postoperative intraocular pressure (IOP) between the 2 groups.

Results: 220 eyes of 220 patients were included. The mean external width of the incision in Group A was much smaller than that in Group B ($P < .01$), and the consistency of the incision diameter in Group A was better than that in Group B. There was no statistically significant difference in incision length between the 2 groups ($P = .75$). 1 day after surgery, there was no statistically significant difference in incision morphology between the 2 groups ($P = .72$). The operating time for Group A was significantly shorter than that of Group B ($P < .01$). There was no obvious incision leakage in both groups after surgery, and the IOP was generally elevated after surgery, but there was no significant statistical difference between the 2 groups ($P = .98$).

Conclusions: The present study suggests that a near-square side-port results in better consistency of incision width and shorter surgical time.

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Cataract is still the leading cause of blindness in the world. Phacoemulsification is the standard surgical treatment of cataract in many countries and one of the most commonly performed surgeries in the world.[1,2] This procedure is usually performed through a major incision and a side-port corneal incision.[3] Previous studies have found that main incisions of differing sizes have different effects on postoperative intraocular pressure (IOP), uncorrected distance visual acuity, astigmatism, and anterior and posterior corneal surface higher-order aberrations.[4–7] However, few studies have been specifically focused on side-port incisions; only Venugopal et al. emphasized the importance of the side-port incision structure in cataract surgery.[8]

The role of side-port incision in cataract surgery is primarily to provide auxiliary functions. For example, the injection of viscoelastic agents; for hydrodissection and hydrodelineation, insert a blunt cannula through the side-port incision.[9,10] To assist in emulsifying the broken nucleus, insert the chopper through the side-port incision or, if necessary, use the manipulator to adjust the position of the eyeball and intraocular lens (IOL).[11] During the process of performing bimanual phacoemulsification or anterior vitrectomy, the irrigation and aspiration (I/A) handle piece is inserted through the side-port incision to facilitate the removal of cortical layers from various directions.[10] The width of the side-port incision is usually between 0.5 mm and 1.0 mm.[8] If the incision is too small, it will impede the access of instruments to the anterior chamber and make the operation more difficult. If the incision is too wide, it may result in incision leakage, increasing the risk of intraoperative surge in the anterior chamber.[12,13] In addition, postoperative incision leakage will increase the incidence of

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infectious endophthalmitis.[14] Iris prolapse is a common complication in cataract surgery and is usually due to pressure changes and fluid egress from within the eye. When the side-port incision is too large, the iris can also prolapse because of fluid egress from the anterior chamber.[15] Therefore, a suitable auxiliary incision is essential for a perfect cataract surgery. Some surgeons choose to use a 15-degree blade to create a side-port incision, and the blade has an uneven triangular shape and a width of up to 1.4 mm, resulting in an asymmetric trapezoid side-port incision.[8] The ideal width of the incision should be less than 1 mm, and the surgeon must have a lot of experience to make a suitable incision. In recent years, some operators have used a 23-gauge microvitreoretinal (MVR) blade, an equilateral prismatic blade with a width of up to 0.93 mm, resulting in a near-square side-port incision. The aim of this study was to compare the precision, safety, and operability of asymmetric trapezoid and near-square lateral incision in the hope of providing guidance for clinical work.

METHODS

Statement

This study was approved by the Institutional Review Board of the Aier Eye Hospital of Wuhan University (China) and was performed in accordance with the tenets of the Declaration of Helsinki. After receiving an explanation of the nature of this study, all patients provided informed consent.

Patient Population

Patients with age-related cataracts who had surgery between April 2022 and September 2022 at Wuhan Aier Eye Hospital were selected for this study. The 220 patients were divided into Group A and Group B using the random number table method. Each group contained 110 patients. Group A was given a near-square side-port incision, and Group B was given an asymmetric trapezoid side-port incision.

Inclusion criteria were as follows: patients diagnosed with age-related cataracts according to the Lens Opacities Classification System III, patients were conscious and able to communicate normally, and patients who gave informed consent.[16] Exclusion criteria were as follows: glaucoma, uveitis, or retinal disease; prior ophthalmic surgery or trauma; systemic diseases such as diabetes mellitus, thyroid disease, and autoimmune diseases; major complications associated with surgery such as macular edema, significant uveitis, and conjunctivitis; and ocular surface diseases such as corneal disease, significant lid gland dysfunction, entropion or ectropion, and trichiasis.[7]

All patients underwent ophthalmologic examinations, including postoperative IOP measurement, slitlamp microscope examination, and anterior-segment examination. The same experienced examiner performed all examinations.

Data Measurement

The incision width, which includes the external and internal diameters of the incision, is measured by importing the surgical images into computer-aided image analysis software (Image-Pro Plus 6.0) and using the value of the scale line on the 2.2-mm blade as a unit of measurement before performing the measurement (according to the manufacturer, the diameter of the scale line on the 2.2-mm blade is 0.6 mm). The true size of the incision diameter is then calculated by the ratio of the incision width and scale line. The above operation is repeated 3 times, and the average of the 3 results is taken.

The incision length was measured on the first postoperative day by anterior-segment optical coherence tomography (AS-OCT) using a CASIA2 device (Tomey Corp.), with the epithelial side of the corneal incision as the starting point and the endothelial side of the incision as the end point. The line between the 2 points is the length of the lateral incision to be measured.[17]

Morphology of the incision was assessed by AS-OCT. Following Doeller et al., we classified the morphology of the incision into 5 categories—endothelial gaping, epithelial gaping, local detachment of Descemet membrane, loss of coaptation, and good coaptation (Figures 1–4).[18] An incision with the diameter of the 2 broken ends of >0.1 mm was recorded as endothelial gaping, and good coaptation was recorded if the endothelial gaping diameter was less than 0.1 mm and did not combine with other types of incision patterns, such as local detachment of Descemet membrane and loss of coaptation.

All incisions were observed for leakage on the day after surgery using a 2% fluorescein Seidel test.[18] IOP values were measured by the same person using a rebound tonometer (ICare, Tiolat) on the postoperative day 3 times per eye, and the final average of the 3 measurements was taken.

The surgical video was imported to Python professional video analysis software. The time of making the side-port incision is specifically the time from the tip of the knife piercing the cornea to the time of pulling out the blade after penetrating into the anterior chamber. Each video was measured 3 times, and the final average of the 3 times was taken.

Surgery Method

Preoperatively, the pupil was dilated with 1.0% topical tropicamide and a topical anesthetic agent in the form of 0.4% proparacaine hydrochloride was administered once. The surgery was performed by the same experienced cataract surgeon (Y.W.). The surgeon operated on the patient using the same chopper. Cortical cleanup and removal of the ophthalmic viscosurgical device (OVD) were achieved using the angled I/A tip of the standard INTREPID (Alcon Laboratories, Inc.) microincision surgical device profile (Alcon Laboratories, Inc.). The inner and outer diameters of the cannula were 0.6 mm and 0.9 mm.[19] Group A had a 2.2-mm clear corneal main incision at 120 degrees and a side-port incision at 30 degrees using a 23-gauge MVR blade (SUS302 stainless steel blade, Mani, Inc.) to create a near-square side-port incision, with 0.93 mm at the widest point of the blade. Group B had a main incision at the same position and a side-port incision at 30 degrees using a 15-degree blade (SUS302 stainless steel blade) to make an asymmetric trapezoid side-port incision, with 1.4 mm at the widest point of the blade. Next, an OVD was injected into the anterior chamber through the main incision, and a 5.2-mm continuous curvilinear capsulorhexis was created with a microforceps. Phacoemulsification (Infiniti, Alcon Laboratories, Inc.) was performed to aspirate the nucleus after hydrodissection with a balanced salt solution, and then the cortex was aspirated. This was followed by aqueous polishing, injection of the OVD from the main incision into the anterior chamber, and implantation of the foldable IOL into the capsular bag. After the OVD was removed, the incisions were sealed by stromal hydration without sutures. The entire procedure was recorded with a high-definition video camera (Sony Exmor HD 3CMOS, Sony Group), and the recorded video was used for data analysis. Postoperatively, patients were treated with tobramycin dexamethasone eyedrops (TobraDex) 3 times daily for 4 weeks. In addition, 0.3% sodium hyaluronate eyedrops were administered 4 times daily for 2 months postoperatively.

Statistical Analysis

All statistical analyses were performed with SPSS v. 22 (SPSS, Inc.), and quantitative data were expressed as means ± SDs if they conformed to a normal distribution or as median (interquartile spacing) if they did not. The Shapiro-Wilk test was used to test whether the data conform to normal distribution. Qualitative data

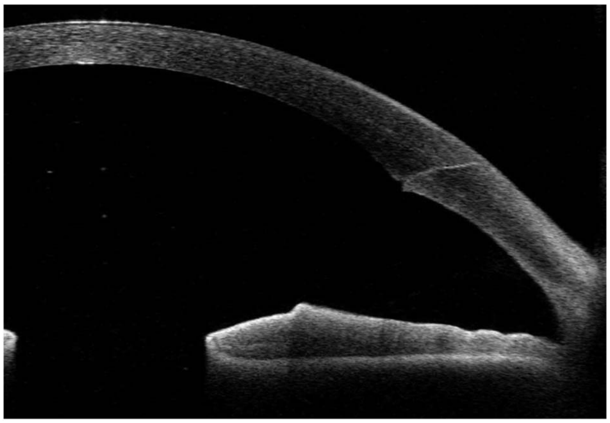

Figure 1. An AS-OCT image of a CCI 1 day postoperatively. This image shows gaping at the endothelial side of the CCI. CCI = clear corneal incision

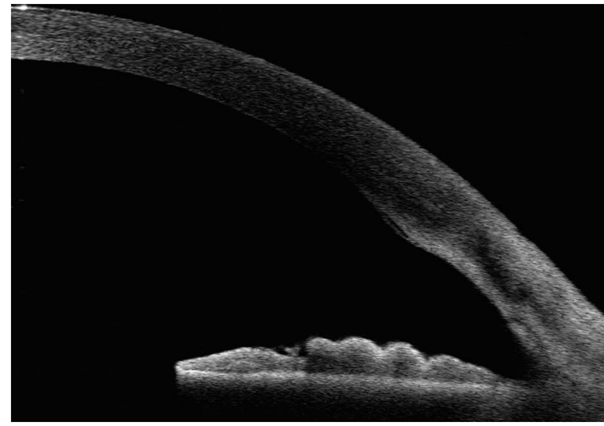

Figure 2. An AS-OCT image of a clear corneal incision 1 day postoperatively. This image shows stripping of Descemet membrane.

were expressed as proportions (%). The test showed that the data (age, preoperative IOP value, postoperative IOP value, incision length and width, and time to make a subsidiary incision) conformed to normal distribution; therefore, the comparison of these data were performed using an independent samples *t* test, and the comparison of postoperative incision architecture between the 2 groups was performed using the Fisher exact probability method. A 2-sided *P* value less than 0.05 was considered statistically significant.

RESULTS

The study assessed data from 220 eyes, 110 in each of Group A and Group B. None were excluded, and no data were missing. Table 1 summarizes the basic information of the study population. In total, 220 eyes were examined. There was no significant difference between the 2 groups ($P > .05$). All patients had a 2% fluorescein Seidel test performed by an experienced surgeon 1 day postoperatively. No incision leakage occurred in either group.

Incision Diameter

The outer diameter of the incision was 0.838 ± 0.035 mm (range 0.75 to 0.91 mm) in Group A and 0.959 ± 0.099 mm (range 0.71 to 1.31 mm) in Group B. The outer width of the incision in Group A was significantly smaller than that in Group B ($P < .01$), and the standard deviation of the data in Group A was significantly smaller than that in Group B. Therefore, the consistency of the outer width of the incision in Group A was better. The internal and external diameters of the incision in Group A were consistent; however, the external width was greater than the internal width of the incision in Group B ($P < .01$) (Table 1).

Incision Length

The side-port incision mean length was 1.329 ± 0.309 mm (range 1.043 to 1.576 mm) in Group A and 1.309 ± 0.358 mm (range 0.968 to 1.771 mm) in Group B ($P = .75$) (Table 1).

Incision Architecture

Table 2 summarizes the results of the incision morphology in Groups A and B 1 day postoperatively. Some patients in both groups had endothelial dehiscence and local detachment of Descemet membrane in both groups postoperatively. Loss of coaptation was seen in 4 cases in Group

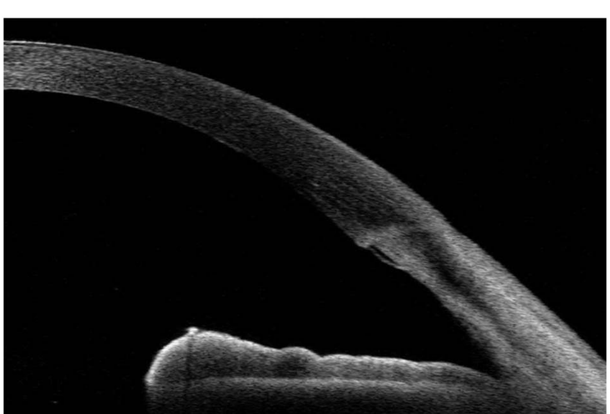

Figure 3. An AS-OCT image of a CCI 1 day postoperatively. This image shows loss of coaptation along the CCI tunnel. CCI = clear corneal incision

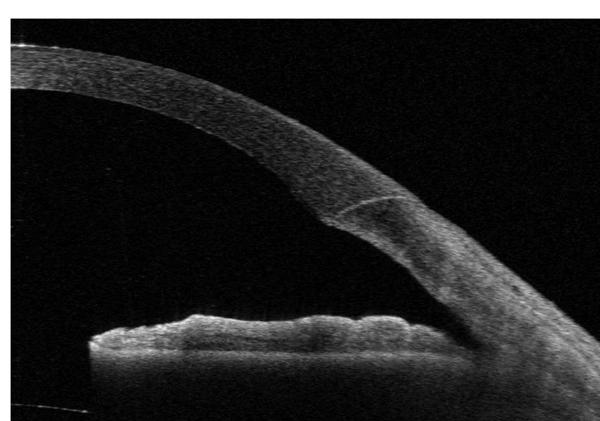

Figure 4. An AS-OCT image of a clear corneal incision 1 day postoperatively. This image shows good coaptation.

Table 1. Assessment of the collected data

Parameters	Group A (n = 110)	Group B (n = 110)
Age (y)	69.58 ± 6.09	67.05 ± 9.71
Sex (M/F)	59/51	57/53
Preop IOP (mm Hg)	14.49 ± 2.58	14.49 ± 3.42
Internal width of incision (mm)[a]	0.838 ± 0.035	0.663 ± 0.062
External width of incision (mm)[a]	0.838 ± 0.035	0.959 ± 0.099
Incision length (mm)	1.329 ± 0.309	1.309 ± 0.358
Postop IOP (mm Hg)	17.16 ± 4.60	17.17 ± 5.28
Surgical time (ms)[a]	1360.67 ± 261.74	2971.13 ± 316.03

[a]$P < .001$ between Group A and Group B

B (3.6%). No epithelial gaping was seen in either group. The probability of good coaptation was 45.4%% in Group A and 46.3% in Group B. There was no difference in the postoperative incisional morphology between the 2 groups ($P = .27$).

Postoperative IOP

The mean postoperative IOP was 17.16 ± 4.60 mm Hg in Group A and 17.17 ± 5.28 mm Hg in Group B 1 day postoperatively ($P = .98$) (Table 1).

Surgical Time

Table 1 presents the surgical time to make the side-port incision, which was 1360.67 ± 261.74 ms (range 810 to 1850 ms) in Group A and 2971.13 ± 316.03 ms (range 2280 to 3670 ms) in Group B. The time to make the near-square side-port incision with the 23-gauge MVR blade was significantly shorter than the time to make the asymmetric trapezoid side-port incision with the 15-degree blade ($P < .01$).

DISCUSSION

Phacoemulsification cataract surgery is currently the main treatment of cataracts. Various operations can be performed through a main incision and subsidiary incision, with the side-port incision playing more of an auxiliary role, such as assisting in splitting the nucleus and adjusting the IOL position. The evaluation of whether a side-port incision is ideal is based on 3 main considerations—precision, safety, and surgical time. Varma et al. suggested that the side-port incision should be 1.0 mm wide for the external incision and 0.5 mm wide for the internal incision.[20] This not only reduces leakage but also uses the incision as a fulcrum to reduce tissue trauma. In their experiment, Jin et al. used a 1.0-mm side-port incision, but many other studies have used different sizes of side-port incisions to successfully complete cataract surgery.[21] For instance, Hayashi et al. made a 0.6-mm subsidiary incision.[17] The postoperative incision closure in both studies was optimal.

The appropriate size of the intraoperative subsidiary incision affects the flexibility of the surgical instruments in the anterior chamber during surgery. A side-port incision that is too small will restrict the tool's working range and its ability to perform its auxiliary function, leading to subpar cataract surgery. Our study results revealed a statistically significant difference between the patients in Groups A and B in the intraoperative external diameter of the incision when comparing the precision of subsidiary incision making. The outer diameter of the incision in Group A was significantly smaller than that of group B, and the consistency of the external width of the incision in Group A was greater than that of Group B. These differences may have occurred because when making an asymmetric trapezoid incision with a 15-degree blade, the widest point of the blade is 1.4 mm, which is much wider than 1.0 mm. When performing a subsidiary incision, the depth of the blade puncture into the anterior chamber relates to the surgeon and surgeon's experience. It is difficult to guarantee that the depth of the blade puncture into the anterior chamber is the same every time, even for the same surgeon. However, the diameter of the near-square incision is equivalent to the widest point (0.93 mm) of a 23-gauge MVR blade, and it is not affected by the experience of the surgeon or different surgeons. Accordingly, the subsidiary incision created by a 23-gauge MVR blade is smaller, the incision uniformity is better, and it is more beneficial to patients' postoperative recovery.

In comparing the internal and external widths of the incision, they were similar using a 23-gauge MVR blade; it is a near-square subsidiary incision. However, the incision's external width was greater than the incision's internal width using a 15-degree blade; it is an asymmetric trapezoid side-port incision. This discrepancy is attributable to the morphology of the 2 blades.

In cataract surgery, a consistent inner and outer incision width facilitates the flexibility of the surgeon's intraoperative instrumentation and the stability of the incision. Some studies have shown that a square or nearly square incision is more resistant to intraoperative and postoperative wound distortion and more conducive to reducing intraoperative and postoperative leakage. It also

Table 2. Comparison of incision morphology 1 day postoperatively

Group	Epithelial gaping	Endothelial gaping	Local detachment of Descemet membrane	Loss of coaptation	Good coaptation	
Group A	0	28 (25.4)	32 (29.1)	0	50 (45.4)	
Group B	0	24 (21.8)	31 (28.1)	4 (3.6)	51 (46.3)	
Fischer value						4.055
P value						.27

improves intraoperative anterior chamber stability and enhances surgical safety.[22] Apparently, the near-square incision is more advantageous. Regarding incision length, there was no statistically significant difference between the 2 groups, possibly because the intraoperative side-port incisions we made were single-plane and the same surgeon operated on all the patients.

In assessing safety, there were no statistically significant differences between the 2 groups regarding the incision morphology on the postoperative day. On the endothelial side, different degrees of endothelial dehiscence occurred in some patients while on the epithelial side, all incisions were well-coaptated. Our results were consistent with those of Torres et al. in that all incisions on the epithelial side occurred with adequate coaptation, regardless of the incision angle and surgeon's experience.[23]

The local detachment of Descemet membrane was also common in postoperative incision patterns, probably because of mechanical forces acting on the cornea during the procedure.[24] In our study, the incidence was 29.1% and 28.1% in 2 groups. This was lower than the percentage in the study by Calladine et al., which may be because of greater mechanical force acting on the main incision than on the side-port incision during the procedure.[18] In conclusion, although some degree of corneal damage occurred postoperatively, it did not affect the stability of the incision. Corneal healing was confirmed to occur faster, with significant improvement in the damaged incision occurring within 1 week.[23]

Our study found no significant subsidiary incision leakage. In one of the few studies that considered side-port incisions, Chee found some incision leakage when povidone–iodine testing was performed after cataract surgery, but when the integrity of the incision was reassessed with fluorescein 1 day postoperatively, no incision leakage was found.[14] This is consistent with our results.

Previous studies have shown that a clear corneal incision (CCI) provides a pathway for bacteria and other substances to enter the anterior chamber and causes postoperative endophthalmitis and is a risk factor of postoperative endophthalmitis.[25,26] According to the results of a study on CCIs undertaken in Singapore, side-port incision leakage accounted for two thirds of the postoperative incision leakage that occurred in the 33 eyes in the study. This leakage could potentially lower postoperative IOP below the threshold, indicating that postoperative leakage from a side-port incision should also be a concern. When postoperative IOP decreases, the integrity of the CCI is compromised.[18,27–29] Taban et al. reported that an amount of India ink similar in size to bacterial particles can enter the anterior chamber in the low IOP state that occurs immediately postoperatively.[30] Although the near-square incision made with the 23-gauge MVR blade and the asymmetric trapezoid incision made with the 15-degree blade both have equally good incisional closure, we hypothesize that patients with a near-square side-port incision have a somewhat reduced risk of postoperative endophthalmitis and low IOP.

There were no statistically significant differences in IOP on the postoperative day between Groups A and B. The results were similar to those of Hayashi et al., who measured IOP preoperatively; at the end of surgery; and 30 minutes, 60 minutes, 120 minutes, 180 minutes, and 24 hours postoperatively in 128 eyes in which different lengths of CCIs were used.[17] The results of their study showed that the differences in mean IOP between the long and short incision groups were not statistically significant at any of the follow-up time points. In contrast to Hayashi et al., whose patients' IOP values returned to preoperative levels at 24 hours postoperatively, the results of our study showed a slight increase in IOP values at 24 hours postoperatively in both groups compared with preoperative values, which may be related to the surgical operation.[17]

In a comparison of operative parameters for incision creation, we found that the surgical time to make a near-square side-port incision was significantly shorter than that for an asymmetric trapezoid side-port incision, and there was a statistically significant difference between the two. This is because the widest point of the incision with the 15-degree blade is 1.4 mm, whereas the ideal width of the incision is less than 1 mm. Therefore, the surgeon needs to create the incision carefully to ensure that the depth of the blade into the anterior chamber is appropriate and the size of the created incision is appropriate. The completion of this process consistently and smoothly requires the surgeon's accumulated surgical experience, and the asymmetric trapezoid incision is not convenient enough for novice surgeons. A near-square incision is much easier to operate, with its widest point being 0.93 mm and spear-shaped, so that the inner and outer openings have the same diameter. As the surgeon does not have to consider the depth of the blade penetration into the anterior chamber, this saves a lot of time and it is more suitable for surgeons with relatively little clinical experience.

Although the sample includes 110 patients in each group, wider studies should confirm our conclusions. Our findings cannot be generalized to every patient who underwent phacoemulsification cataract surgery. Consequently, further studies with a larger sample size are needed for follow-up. Another limitation of our study is that we did not observe the relationship between postoperative IOP and incisional morphology in our patients. The flattening effect of the main incision may be affected by the side-port incisions, although this issue has not been analyzed and could be studied in further research.

While both the asymmetric trapezoid and near-square side-port incisions are safe to use in cataract surgery, our research demonstrates that the near-square side-port incision has advantages over the asymmetric trapezoid side-port incision for simplicity of operation and precision, as well as being more readily accessible.

WHAT WAS KNOWN

- At present, phacoemulsification is mainly performed through a main incision and 1 or 2 lateral incisions to complete a series of operations, and the closure of the incision is significantly related to the incidence of complications. Previous studies comparing major incisions of different sizes have been numerous, but there are fewer data on side-port incisions.

WHAT THIS PAPER ADDS

- We found that both the asymmetric trapezoidal side-port incision and the near-square side-port incision had good closure postoperatively. However, the consistency of the near-square incision is better, and the operation is more convenient, so it has a wider range of clinical applications.

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