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Open-sky capsulorrhexis in triple procedure: with or without trypan blue?

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PURPOSE. *To establish the beneficial effects of trypan blue 0.1% capsule staining in open-sky capsulorrhexis during triple procedure.*
METHODS. *Patients who underwent penetrating keratoplasty (PK) with phacoemulsification and intraocular lens (IOL) implantation were divided into two groups. Group 1 consisted of 31 eyes of 26 patients with a mean age 64.4 ± 6.9 years and anterior lens capsule was stained with trypan blue 0.1% to perform open-sky capsulorrhexis. In Group 2, capsulorhexis was performed without staining of the anterior capsule in 19 eyes of 17 patients with a mean age 60.6 ± 5.3 years. The rates of complete capsulorrhexis and intra- and postoperative capsule-related complications were compared between the groups.*
RESULTS. *The most common diagnosis before PK was corneal opacification in both groups. Open-sky capsulorrhexis was not completed in 3 eyes (9.6%) in Group 1 and in 9 eyes (47.3%) in Group 2. The rates of incomplete capsulorrhexis, posterior capsule tear, and transscleral fixation IOL implantation were higher in Group 2 (for each, $p < 0.05$). The diameters of capsulorrhexis were smaller than 4.5 mm in one eye in Group 1 and in two eyes in Group 2, and larger than 6.5 mm in two eyes in Group 1 and in three eyes in Group 2. Malposition of IOL, zonular dialysis, retinal detachment, and pupil capture were only observed in eyes in Group 2. In the follow-up period, there were no adverse reactions due to application of trypan blue in Group 1.*
CONCLUSIONS. *Trypan blue staining of the anterior capsule during triple procedure helps the surgeon perform open-sky capsulorrhexis more easily and safely and in proper dimensions, provides positive effects on the other steps of the surgery, and decreases the rate of posterior capsule tear formation. (Eur J Ophthalmol 2003; 13: 764-9)*

KEY WORDS. *Trypan blue staining, Triple procedure, Open-sky capsulorrhexis*

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INTRODUCTION

Cataract formation is more common in patients with Fuchs' dystrophy or in patients in whom inflammation or trauma has been a factor for corneal opacity. In addition, visually significant corneal opacification can prevent the evaluation of the lens opacities. To coincide with cataract during penetrating keratoplasty (PK) is not uncommon. In these situations, cataract extraction and intraocular lens (IOL) implantation with PK (triple procedure) can be performed (1, 2). The triple procedure is a well-established surgical procedure for the single-stage treatment of cataracts and concurrent corneal opacity. This procedure allows faster visual rehabilitation without increasing the incidence of complications or adversely affecting graft survival.

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During triple procedure, performing of anterior capsulorrhexis allows for better centration and stability of the IOL (3, 4). However, a capsulorrhexis may be very difficult to perform in patients with mature cataract due to absence of a red reflex. Staining of the anterior capsule with trypan blue 0.1% is one of the methods to visualize the capsulorrhexis borders (5-7).

This study evaluated the beneficial effect of trypan blue 0.1% on performing open-sky capsulorrhexis in triple procedure and capsule-related complications encountered during or after surgery. To our knowledge, this is the first study to report the use of trypan blue 0.1% in open-sky capsulorrhexis.

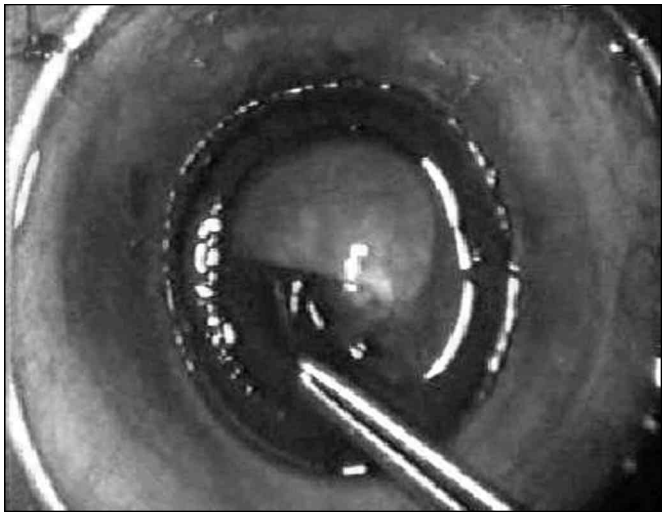

Fig. 1 - *Performing the open-sky capsulorrhexis after staining of anterior capsule.*

MATERIALS AND METHODS

Fifty eyes of 43 patients (25 men, 18 women) who underwent triple procedure between March 1999 and December 2002 were included in this prospective nonrandomized clinical trial. All patients had mature cataract, which was determined before or during PK. The most common indication for PK was corneal scarring. The patients were divided into two groups. In Group 1 (n = 31 eyes), anterior lens capsule was stained with trypan blue 0.1% and open-sky capsulorrhexis was performed. In Group 2 (n = 19 eyes), open-sky capsulorrhexis was performed without staining of anterior capsule.

Preoperative evaluation included assessment of visual acuity, slit-lamp biomicroscopy, measurement of intraocular pressure (IOP), and ultrasonographic (A and B scan) examination. The emmetropic IOL power was calculated with SRK-II formula. The fellow eyes were considered for the preoperative keratometry readings of the eyes in which adequate readings could not be obtained. Age, sex, diagnosis, and intra- and postoperative capsule-related complications were recorded.

Operative technique

Before surgery, all patients received IOP-lowering treatment including oral carbonic anhydrase inhibitors (acetazolamide, 250 mg) and intravenous hyperosmotic agents (Mannitol, 5 ml/kg). All operations were performed under general anesthesia with 1 to 1.5% sevoflurane (Abbott Laboratories, Turkey) in 33 to 66% O_2-N_2O mixture and nondepolarizing muscle relaxant (vecuronium 0.1 $mg.kg^{-1}$) by a single surgeon (O.A.). The keratoplasty procedure was started by securing a Flieringa ring to the sclera. A 6 mm to 8 mm Hessburg-Barron vacuum trephine was used to make a full-thickness incision, which was completed with corneal scissors. In Group 1, the aqueous was aspirated and 0.1 ml of trypan blue 0.1% was applied to the anterior capsule. The anterior chamber was irrigated with balanced salt solution (BSS) after a few seconds. In Group 2, open-sky capsulorrhexis was performed without staining of anterior capsule. The next steps of the procedure were the same in both groups. A high viscosity material (Healon GV, NY) was injected into the anterior chamber. Using a cystotome needle, a central linear cut and after that a continuous curvilinear capsulorrhexis was performed (Fig. 1). Following hydrodissection, phacoemulsification was used when the nucleus was too large to pass through the capsulorrhexis. All eyes were implanted with a one-piece polymethyl methacrylate posterior chamber IOL with 5.5 mm diameter biconvex optic. Carbachol was administered to maintain pupillary constriction through the rest of the procedure. The donor cornea was sutured with 16 interrupted and one running 10-0 nylon suture to the recipient bed. At the end of the procedure, gentamicin sulfate and dexamethasone sodium phosphate were given subconjunctivally.

The eyes were examined every day during the first week, weekly during the first month, monthly during the first year, and then every 3 months. At the follow-up examinations, particular attention was given to the capsule-related complications. The width of the capsulorrhexis was assured according to the IOL optic implanted intraoperatively, and by the help of slit-lamp measurement after dilatation of the pupil on the first postoperative day.

The results were expressed as mean ± SD. Chi-square (χ^2) test was used in statistical analysis and $p < 0.05$ was considered as statistically significant (release 11.0, SPSS Inc., Chicago, IL).

RESULTS

The patients' characteristics and follow-up time of both groups are shown in Table I. The most frequent preoperative diagnosis was corneal scarring (29 eyes, 58%), followed by herpes simplex keratitis (13 eyes, 26%) and Fuchs' dystrophy (8 eyes, 16%) (Tab. I). In all eyes, visual acuities ranged from hand motion to light perception. In 19 eyes, cataract formation was determined during surgery due to corneal opacity, but IOL calculation had been performed before surgery because lens status was invisible. All eyes underwent triple procedure and the same technique was used as mentioned.

In Group 1, open-sky capsulorrhexis was performed successfully in 28 eyes without any complications, but it was not completed in three eyes because of too much posterior pressure. In these eyes, Vannas scissors were used to complete the capsulotomy with as smooth an edge as possible. At the follow-up examination, the diameter of capsulorrhexis was found to be smaller than 4.5 mm in one eye and larger than 6.5 mm in two eyes (Tab. II). There was no residual staining of the capsule and other ocular tissues after surgery and no complications due to application of trypan blue. Malposition of IOL, pupil capture, or retinal detachment was not observed in any eye at the follow-up examinations.

In Group 2, capsulorrhexis was not completed successfully in nine eyes and peripheral radial tear developed. In these eyes, capsulotomy was tried to complete with Vannas scissors. Posterior capsule tears occurred in four eyes and zonular dialysis was observed in one eye. In these eyes, the IOL was not inserted in the capsular bag, and anterior vitrectomy was performed to remove the vitreous from the anterior chamber and around the iris and capsule, and transscleral fixation posterior chamber lens was in-

TABLE I - PATIENT CHARACTERISTICS

Characteristics	Group 1	Group 2
Number of patients	26	17
Number of eyes	31	19
Mean age *(years)*	41.0±15.0	46.7±15.3
Sex		
Female	10	8
Male	16	9
Eye		
Right	*17*	*10*
Left	14	9
Diagnosis		
Fuchs' dystrophy	5	3
Corneal scarring	18	11
Herpes simplex keratitis	8	5
Mean follow-up *(months)*	18.2±5.4	19.3±5.6
Preoperative IOP (mmHg)	16.6±2.2	17.0±2.3
Postoperative IOP (mmHg)	17.2±2.5	17.6±2.8

Values are mean ± SD
IOP = Intraocular pressure

TABLE II - COMPLICATIONS ENCOUNTERED DURING PERFORMANCE OF OPEN-SKY CAPSULORRHEXIS

Complications	Group 1	Group 2
Incomplete capsulorrhexis*	3/31 (9.6%)	9/19 (47.3%)
Posterior capsule tear*	0	4/19 (21.0%)
Diameter of capsulorrhexis		
>4.5 mm	1/28 (3.5%)	2/10 (20%)
4.5-6.5 mm*	25/28 (89.2%)	5/10 (50%)
<6.5 mm	2/28 (7.1%)	3/10 (30%)
IOL malposition	0	2/19 (10.5%)
Pupil capture	0	1/19 (5.2%)
Zonular dialysis	0	1/19 (5.2%)
Transscleral IOL implantation*	0	5/19 (26.3%)
Retinal detachment	0	1/19 (5.2%)

*Statistically significant
IOL = Intraocular lens

serted. Retinal detachment occurred in one eye with transscleral fixation IOL 16 months after surgery. The patient underwent scleral buckling and the retina was attached after surgery and the visual acuity improved to finger counting from 5 m. The rates of smaller and larger capsulorrhexis are shown in Table II. Malposition of IOL developed in two eyes and pupil capture was observed in one eye with peripheral radial capsule tear. There were no such complications in eyes in which capsulorrhexis was successfully performed in both groups.

The rates of incomplete capsulorrhexis, posterior capsule tear, transscleral fixation IOL implantation, and total complications were significantly higher in Group 2 (for each, $p < 0.05$). Although the rates of malposition of IOL, zonular dialysis, pupil capture, retinal detachment, and improper dimensions of capsulorrhexis were higher in Group 2, there were no significant differences between the two groups (for each, $p > 0.05$).

DISCUSSION

It is a dilemma whether to perform PK alone or in combination with cataract extraction in the presence of lens opacities. The advantages of triple procedure are allowing faster visual rehabilitation without increasing the incidence of complications and adverse effects compared to performing cataract extraction after PK (8, 9). The success rates of various studies on the outcome of the triple procedure have ranged from 73% to 94% of clear grafts (10-12). Therefore, we favor the simultaneous-procedure approach and agree with its major advantages as follows: 1) single surgery, 2) less cost, 3) endothelial preservation of the donor cornea (13, 14).

One of the most important steps in triple procedure is performing of capsulotomy. When capsulotomy techniques are compared, continuous circular capsulorrhexis has a number of advantages over anterior capsulotomy. It contributes significantly to the safety and effectiveness of cataract extraction and IOL implantation and produces a strong capsular rim that resists tearing even when stretched during lens material removal or lens implantation. Also, it facilitates such procedures as hydrodissection, endolenticular phacoemulsification, complete cleaning of the capsular bag, and capsule polishing, and allows better centration and stability of the posterior chamber IOL. It also reduces the occurrence of a posterior capsular tear (15, 16). Can opener capsulotomy usually results in radial tears. These radial tears can enlarge and affect IOL placement and stabilization and may cause IOL dislocation. The rates of such complications may be higher in open-sky conditions because of too much posterior pressure when compared with closed-system. In closed-system cataract extraction, Akkin et al (17) reported higher rates of IOL decentration in eyes that underwent envelope technique than eyes with continuous curvilinear capsulorrhexis. In our study, there was no malposition of IOL in eyes in which capsulorrhexis was successfully completed. The rate of malposition of IOL in Group 1 was 0%, whereas it was 10.5% in Group 2. These findings were compatible with other studies (18).

It is very useful to observe the red fundus reflex while performing capsulorrhexis. It allows visualization of the outline of the capsulorrhexis. However, fundus reflex is absent in eyes with mature cataracts and heavily pigmented fundi. In this situation, it may be very difficult to perform capsulorrhexis and techniques to visualize the anterior capsule are required. These are the use of side illumination (19), hemocoloration of the capsule with autologous blood (20), subcapsular injection of fluorescein (21), and the use of capsule dyes (6). The first three techniques are time consuming to perform, and hemocoloration requires preoperative preparation of hemoderivate.

As capsule dyes, trypan blue 0.1%, gentian blue 2%, indocyanine green 0.5%, cresyl blue 1%, and methylene blue 5% are able to stain the anterior capsule. It was found that methylene blue 1% and gentian violet 0.1% increased the incidence of corneal edema, and brilliant cresyl blue 1% has not been used in the human eye *in vivo* (7).

Trypan blue 0.1% capsule staining is a safe and effective technique to facilitate the performance of a capsulorrhexis in the absence of a red reflex fundus (7). Although trypan blue capsule staining was reported in closed-system cataract extraction, the use of trypan blue has not been reported in triple procedure. To our knowledge, this study is the first to report the beneficial effects of trypan blue in open-sky capsulorrhexis. In the open-sky condition, there is no pressure on the anterior capsule as in a closed-system

cataract extraction. This may cause incomplete capsulorrhexis, unintended extension of the capsule tear toward the periphery, and incomplete irrigation and aspiration of cortex, and the open-sky period may lead to posterior capsular rupture, vitreous loss, and predisposition to choroidal effusion and suprachoroidal hemorrhage. All these factors may enhance the stress of the surgeon. Therefore, visibility of the capsule borders is important to finish the capsulorrhexis successfully and capsulorrhexis facilitates the next steps of the surgery and decreases the rate of late complications. In our study, we obtained quick, homogeneous staining of the anterior capsule with trypan blue 0.1% and trypan blue enabled us to visualize the outline of the capsulorrhexis in all cases. It was easy enough to distinguish the anterior capsule from the lenticular mass. In some eyes with mature cataract, the lens may become swollen. During performance of central linear cut with a cystotome, sudden rupture of anterior capsule may develop. If the anterior capsule is not stained with trypan blue, it will be very difficult to distinguish the edge of the capsule tear. If the surgeon insists on performing capsulorrhexis, it will be inevitable to develop peripheral extension of capsule tear and formation of posterior capsule tear. Therefore, we recommend staining of anterior capsule in all eyes with mature cataract and invisible anterior capsule. In only three eyes in Group 1, we did not complete capsulorrhexis because of too much posterior pressure or sudden rupture of anterior capsule. In Group 1, the diameter of capsulorrhexis was between 4.5 and 6.5 mm in 25 eyes and it was statistically higher when compared with Group 2. The rates of incomplete capsulorrhexis, posterior capsule tear, and transscleral fixation IOL implantation were statistically higher in Group 2 because of the invisibility of the capsule borders.

In conclusion, trypan blue staining of the anterior capsule during triple procedure enables the surgeon to complete the open-sky capsulorrhexis successfully and in proper dimensions, prevents the formation of posterior capsule tear, provides positive effects on the next steps of the surgery, and decreases capsule-related complications.

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