Application of an iris speculum for removing Soemmering ring during secondary intraocular lens implantation in congenital cataract patients with small pupils

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**Short running head:** Application of an iris speculum
Abstract

An application of the XpandNT iris speculum in eyes with small pupils during secondary intraocular lens (IOL) implantation in congenital cataract patients is described. The iris speculum was first positioned in the eye to expand the pupil. A 30-gauge needle was used to separate the adhesion of the iris tissue and the capsular rim. Vitrectomy was used to clean Soemmerring ring near the capsular rim. The iris expander was retracted with the Williamson XpanNT Manipulator. The IOL was then implanted. Fourteen aphakic eyes from 10 consecutive patients were studied retrospectively; pupil expansion was achieved in all 14 eyes intraoperatively without serious intraoperative or postoperative complications. The XpandNT iris speculum was a safe and excellent tool for removing Soemmerring ring and solving small pupil problems during secondary IOL implantation in pediatric cataract surgery patients.

Introduction

Congenital cataracts are one of the most threatening visual diseases in children. The size and rapid growth of children’s eyes makes intraoperative intraocular lens (IOL) implantation after age 2 safer and more desirable. However, poor pupillary dilatation with pharmacologic agents is a common problem in secondary IOL implantation for congenital cataracts. Thus, removing the grown cells within Soemmerring’s ring presents a clinical challenge in cases of small pupils during secondary IOL implantation in congenital cataract patients. Ensuring adequate pupillary dilatation presumably reduces the risk of complications such as zonular
dehiscence, capsular rim rupture and iris trauma, which makes the surgery much safer. Pupil expanders are popularly used for small pupils during cataract surgeries due to less trauma.\textsuperscript{3-6}

The recently developed XpandNT (Diamatrix Ltd.) iris speculum, a pupil expander, provides a near-circular opening that is 6.7 mm in diameter. Here, a technique for maintaining a large pupil and removing Soemmerring ring with an XpandNT in small pupils is presented.

**Surgical technique**

This study was conducted in accordance with the Declaration of Helsinki and was approved by the ethics committee of Xinhua Hospital affiliated with Shanghai Jiao Tong University School of Medicine, Shanghai, China. Related informed consent was obtained from all participants, and anonymized data extraction was used.

This retrospective study was performed on consecutive aphakic congenital cataract patients who needed secondary IOL implantation and had a small pupil (\( \leq 5.0 \text{ mm} \)) after administration of drug agents at the Department of Ophthalmology, Shanghai Xinhua Hospital, between December 2018 and January 2020. The protocol included acquiring digital videos of the surgery and a 6-month follow-up period. The clinical data included baseline demographics, the operated eye, the preoperative and final intraoperative pupil diameters measured with external calipers, the insertion and removal time of the device, the duration of surgery, and the associated intraoperative and postoperative complications. Intraoperative complications, such as zonular fiber dialysis, capsular rim rupture, hyphema and iris tearing, along with postoperative complications, such as anterior uveitis, corneal edema, raised
intraocular pressure (IOP) (> 21 mm Hg), iris abnormalities and posterior synechiae were recorded.

Fourteen eyes of 10 patients were identified and received a standard preoperative dilating regimen of tropicamide phenylephrine eyedrops every 10 minutes, 4 times. The dilating agent (0.5 mg adrenaline) was routinely added into the 500 ml intraocular infusion to maintain the size of the pupil during surgery. A single surgeon (ZP) performed the surgery using an XpandNT iris speculum after general anesthesia.

The procedure of the surgery was as follows and is shown in Video 1: A superior scleral tunnel incision was performed first to introduce and retract the iris speculum. Then 3 limbal side-port paracentesis incisions were performed to introduce a 20-gauge anterior chamber maintainer and other instruments. (Figure 1A). A view of the iris speculum and the injector is shown in Figure 1B. The proximal scroll of the iris speculum was engaged by a hook and retracted into the injector with two parallel lateral feet that could latch onto each other (Figure 1C). When the injector was introduced into the center of the pupil area through the scleral tunnel incision, the plunger was slowly pushed forward; thus, the first scroll of the iris speculum came out of the injector cannula and easily engaged the inferior pupil margin without the foot dipping up or down (Figure 1D). The nasal and temporal scrolls simultaneously engaged the pupil borders in the horizontal meridian (Figure 1E). Then, the superior scroll was positioned. The small pupil was expanded to capture the proximal margin of the pupil, presenting a circle of approximately 6.7 mm and facilitating visualization of
Soemmerring ring (Figure 1F). A 30-gauge needle was used to separate the adhesion of the iris tissue and the capsular rim (Figure 1G). After removal of the adhesions, the eyeball was pulled with forceps to make the surgical vision of Soemmerring ring clear and to access Soemmerring ring with the vitrectomy probe. The vitrectomy probe was used to inhale, drag and remove Soemmerring ring near the capsular rim (Figure 1H).

Finally, cleaning of Soemmerring ring was finished (Figure 2A). To remove the iris speculum, the nasal scroll was released from the pupil margin with the Williamson XpandNT Manipulator (Diamatrix Ltd.) through temporal side-port paracentesis incisions (Figure 2B). The extended hook from the injector grasped the temporal scroll to retract the device through the nasal side-port paracentesis (Figure 2C). Finally, the iris speculum was successfully retracted in the anterior chamber (Figure 2D). The device was removed after it partially telescoped into the injector (Figure 2E). After the removal of the iris expander, an Alcon AcrySof MA60AC 3-piece IOL was inserted into the ciliary sulcus with optic capture through residual capsular openings as the first choice or simply into the ciliary sulcus due to an unsuitable capsular rim. Finally, wound closure was performed (Figure 2F).

**Results**

Fourteen eyes (9 right eyes) from 10 patients (9 male) were included (Supplemental Table 1). The mean age was 4.8±3.5 years (range, 2-14 years). The mean duration of surgery was 19.3 ± 3.1 minutes (range, 16-24 minutes). The mean size of the pupil before expansion was 4.0 ± 0.8 mm (range, 2.5-5 mm). Fourteen eyes had posterior synechiae before secondary IOL.
implantation. The mean size of the final intraoperative pupil was 4.3 ± 0.7 mm (range, 3.5-5 mm). The insertion time was 56.9 ± 59.9 seconds, while the removal time was 85.9 ± 37.9 seconds. The mean postoperative corrected distance visual distance (CDVA) was 0.57 ± 0.35 logMAR. The follow-up period was 10.5 ± 3.5 months. The ease of insertion and extraction of the expander were assessed by insertion time and removal time. The iris expander was not inadvertently dropped into the vitreous during intraoperative manipulation in any cases. No serious intraoperative or postoperative complications including zonular fiber dialysis, capsular rim rupture, hyphema, anterior uveitis, corneal edema, raised IOP (> 21 mm Hg), iris tearing, iris abnormalities and posterior synechiae were observed during the follow-up. The integrity of the pupil margin and iris root, which were assessed by slitlamp examination, remained intact and returned to a relative physiologic size without iridodialysis or serious distortion. No pupils experienced permanent mydriasis. The pupil shape in all cases was central and nearly round even in some cases of preoperative mild ectopic pupils (Figure 3). In 14 eyes, posterior capsulotomy had already been performed during the initial surgery. IOL was inserted into the ciliary sulcus with optic capture through residual capsular openings in 12 eyes, while in 2 eyes, IOLs were simply inserted into the ciliary sulcus due to an unsuitable capsular rim.

**Discussion**

Removing Soemmerring’ ring contributes to postponement of secondary visual impairment due to postoperative proliferative or inflammatory visual axis opacity for congenital cataract patients who need secondary intraocular lens implantation. During secondary IOL
implantation, a residual asymmetric Soemmerring ring increases the risk of future IOL tilt, and subsequent enlargement of Soemmerring ring may result in the occurrence of uveitis-glaucoma-hyphema syndrome. Insufficient pupil dilation poses a clinical challenge when removing Soemmerring’s ring. Therefore, expanding the surgical field of vision is essential for removal of Soemmerring’s ring during secondary IOL implantation in congenital cataract patients. The pediatric anterior lens capsule is thinner, stronger, and more elastic than the adult anterior lens capsule. The biological characteristics of children’s eyes make secondary IOL implantation for congenital cataracts in patients with small pupils particularly challenging.

There are two definitive methods for pupil dilation: nonmechanical enlargement (such as via pharmacological material and viscosurgical material) and mechanical enlargement. Inflammatory adhesion after initial lens extraction makes pharmacological pupil expansion and the use of a viscoelastic material less effective. The study of Nderitu et al. manifested that the use of mechanical pupil expanders effectively reduced intraoperative risks in cases of small pupil. In the literature, mechanical enlargement of a small pupil during cataract surgery includes pupil stretching, synechiolysis, iris retractors and pupil expansion rings. Pupil stretching results in a smaller final pupil size and a part of miosis during the surgery. Iris manipulation during sphincterotomy triggers exudative transudation into the anterior chamber, thereby increasing the risk of uveitis exacerbation or reactivation. In addition, limited surgical vision and multiple manipulations make removing Soemmerring’s ring difficult compared with using a different type of pupil expansion ring. Iris retractors, such as
iris hooks and Assia pupil expanders, expand the pupil to a rectangular or slightly trapezoidal shape of 6.0 mm or less to avoid iris tears. Maybe a square pupil produced by four iris hooks is not the best shape for a pupil expander because after the retraction, the pupil has difficulty recovering a round shape. In addition, extracorneal incisions might increase surgical astigmatism and obstruct other surgical instruments. Pupil expansion rings, including the Malyugin ring, I-Ring pupil expander, B-HEX pupil expansion ring and Oasis iris expander, are popularly used for solving small pupil problems, and they are faster to use than iris hooks.\textsuperscript{13} The Malyugin ring is distributed worldwide and has a thirteen-year history; however, its mobility occasionally results in iris prolapse to the side-port incision, and it cannot be directly inserted in a very small pupil without another dilation technique.\textsuperscript{15} Previous pupil rings have prevented iris tearing or damage by using organic materials such as polymethylmethacrylate, polyamide and silicone. However, these rings might increase the risks of misshape, rupture and displacement due to their soft nature in cases of serious pupillary adhesion. One-time successful pupil expansion is essential for pediatric patients because failure to expand the iris results in inadequate surgical vision, increases the opportunity for secondary removal of the pupil expander, increases the surgical time and leads to unnecessary iris bleeding. Tan et al. developed a shape-memory expander, but it was only validated in vivo and ex vivo experiments.\textsuperscript{16} The XpandNT iris speculum was mentioned in the review by Malyugin\textsuperscript{3,17} and then by Grzybowski\textsuperscript{11}; it is made of memory nitinol wire, with the midpoint between scrolls resulting in an 8-point octagon fixation of the pupil, providing a near-circular pupil of approximately 6.7 mm in diameter. It was recently evaluated in a series of stage 5 prematurity of retinopathy patients during dissection of the
In this study XpandNT iris speculum safely used in fragile pediatric eyes. However, application of the XpandNT iris speculum for removing Soemmerring ring during secondary IOL implantation in congenital cataract patients with small pupils has not been previously reported.

To our knowledge, this is the first report of the removal of Soemmerring ring with the XpandNT iris speculum during secondary IOL implantation in small pupils using a principle similar to most pupil expanders. There are multiple advantages of this technique. First, like most pupil expanders, it provides wider surgical visualization and management of pupillary adhesion. Second, it rarely drops into the vitreous cavity and engages the vitreous cavity due to stable catching according to the geometric properties. Two pairs of arches anterior to the iris and two pairs of arches posterior to the iris work together as two symmetrical clippers to gently cradle the pupillary margin and provide reliable stabilization. Therefore, two paired anterior arches prevent posterior movement of the iris and vice versa. Third, the key benefit of this new iris speculum is that it is smooth, flexible, minimally invasive, and biocompatible with a 0.003 mm diameter memory nitinol wire, which, to the best of our knowledge, is thinner than any iris speculum on the market. In our experience, it is not necessary to break the posterior synechiae before introducing the device. This iris expander can reset itself by retracting the device back into the injector when the two lateral feet are not parallel. Fourth, although the mean size of the final intraoperative pupil was larger than the pupil size before expansion in our study, which might have been affected by the dilating agent used for infusion, the use of this iris speculum reduced the chance of photophobia caused by
permanent atonic mydriasis and improved the visual quality of life during the follow-up period. However, some details during operation require attention. The injector plunger should be slowly advanced to avoid latched feet and twisting of the device. When the device comes out of the injector cannula, the distal feet gently cradle the pupillary margin without the foot dipping up or down.

Regarding the limitations, the XpandNT iris speculum is relatively expensive compared with existing pupil expanders due to its material, and it is too small to be found once it has been lost. There is still no absolute method to prevent Soemmerring ring in congenital cataract patients. Therefore, removal of Soemmerring ring during secondary IOL implantation aims to maintain a relative period without IOL positioning, reducing the risk for uveitis–glaucoma–hyphema and postponing the recurrence of Soemmerring ring. In addition, this study is a retrospective study with a small number of cases. Further comparison with other pupil expanders is forthcoming. We did not specifically assess corneal endothelial cells as some of the children were uncooperative. In conclusion, although the majority of consultants had a particular preference or experience with either Malyugin rings or iris hooks, we still found that the XpandNT iris speculum was a safe and efficient alternative tool when removing Soemmerring ring. It is minimally invasive for pediatric pupils, and this technique reduces the potential to pinch the capsule and iris or to get stuck in a primary incision.

**What was known**
Pupil expanders have been proven to be effective and safe for expanding the surgical field of view in cases of small pupils.

Previous expanders are easily misshapen, ruptured and displaced, due to their soft nature, in circumstances of serious pupillary adhesion.

**What this paper adds**

The removal of Soemmerring ring with the XpandNT iris speculum during secondary IOL implantation in small pupils was minimally invasive, safe, easy and effective to expand the pupil.

**References**


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**Disclosures:** None reported.

**Figure Legends**

Figure 1

Insertion of the iris speculum. A. Schematic representation of small pupils. Three limbal side-port paracentesis incisions and a superior scleral tunnel incision were performed. B. View of the XpandNT iris speculum and the injector. C. The proximal scroll of the iris speculum is engaged by a hook and retracts into the inserter. D. The plunger is slowly pushed forward into the center of the pupil area through the scleral incision. The device exits the injector cannula, and the proximal scroll of the iris speculum easily engages the inferior pupil margin. E. The lateral scrolls engage the pupil borders in the horizontal meridian. F. The
superior scroll is positioned, and the expanded 6.7 mm pupil with an alternate tucked scroll facilitates visualization of Soemmerring ring. G. A 30-gauge needle is used to separate the adhesion of the iris tissue and the capsular rim. H. Vitrectomy is used to clean Soemmerring’s ring near the capsular rim.

Figure 2
Removal of the iris speculum. A. Cleaning of Soemmerring ring is complete. B. To remove the device, the nasal scroll is released from the pupil margin with the Williamson XpandNT Manipulator. C. The extended hook grasps the temporal scroll. D. View of the extracted device in the anterior chamber. E. The device is removed after it partially telescopes into the injector. F. Surgical miosis of the pupil after removal of the iris speculum.

Figure 3
Preoperative and postoperative pupil of case 5. A. Irregular small pupil and pupillary adhesion before surgery. B. Nearly round pupil after surgery at the 11-month follow up visit.

Video 1:
Application of the Xpan NT iris speculum for removing Soemmerring ring during secondary intraocular lens implantation in congenital cataract patients with small pupils.