Endoscopic Goniotomy With Anterior Chamber Maintainer: Surgical Technique and One-Year Results

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Abstract. The surgical technique of endoscopic goniotomy (EG) using the anterior chamber maintainer (ACM) for congenital glaucoma is evaluated, and one-year follow-up data are presented. Endoscopic goniotomy was performed in 12 eyes of 7 patients. A double-port—special goniotomy knife mounted on the endoscopes probe inserted through the first incision and ACM through the second incision—EG technique was used in 6 eyes of 3 patients, while a three-port—knife, endoscope probe, and ACM inserted through separate incisions—technique was preferred in the remaining 6 eyes of 4 patients. EG of approximately 240° could be done without major complications in all eyes. At the end of the average follow-up period of 14.2 ± 9.7 months, the mean intraocular pressure was reduced from 38.3 ± 6.9 mm Hg to 17.6 ± 2.8 mm Hg {P = 0.002), the average number of glaucoma medications from 2.1 ± 0.3 to 0.3 ± 0.5 (P = 0.001), and the mean cup/disk ratios from 0.84 ± 0.11 to 0.79 ± 0.14 (P = 0.014), while there was no statistically significant change in the average corneal diameter (P = 0.16). Therefore, endoscopic goniotomy with ACM was found to be an effective treatment modality for congenital glaucoma. **[Ophthalmic Surg Lasers 2001;32:496-502]**

INTRODUCTION

The classic defect found in the majority of eyes with primary congenital glaucoma or isolated trabeculodysgenesis is the anterior position of the iris and ciliary body overlapping the trabecular meshwork.[1-5] Because of this finding, the disease is assumed to be the result of an embryonic delay in the iris and ciliary body that prevents normal posterior recession necessary for the development of a normal anterior chamber angle.[1,4,15,17] The abnormal relationship between trabecular meshwork, iris, and the ciliary body probably leads to thickening and composition of the trabecular sheets that will then obstruct the aqueous outflow and increase the intraocular pressure.

A superficial incision of the thickened uveal meshwork by a goniotomy knife will allow the iris root to drop posteriorly with accompanying posterior rotation of the scleral spur, which might then lead to the opening of the corneoscleral trabecular sheets with improved outflow of aqueous.[4,15,17] Schlemm's canal does not appear to be the site of obstruction to aqueous outflow in eyes with primary congenital glaucoma because in early cases no abnormality adjacent to or involving the internal walla of Schleemm's canal has been demonstrated.[2,13]

Although there were numerous studies reporting excellent pressure reductions after goniotomy surgery in eyes with congenital glaucoma,[6,12] two important technical problems encountered during surgery limited the rate of success and even the applicability of goniotomy operations. The first problem was the difficulty in visualizing the angle structure in eyes with opaque corneas, and the second problem was maintaining a deep anterior chamber during the operation.

This study was planned to evaluate whether a technically reliable and effective goniotomy surgery with the help of endoscopic visualization and the anterior chamber maintainer system could be done in **eyes** with corneal clouding caused by congenital glaucoma.

PATIENTS AND METHODS

Enrolled in this study were 12 eyes of 7 **patients** with primary congenital glaucoma **(Table 1).** The diagnosis of congenital glaucoma was made according to the following criteria: corneal enlargement, corneal cloud-

Table 1. Patient Characteristics

Patient No.	Age (months)	Gender	Laterality	Preop IOP (mm Hg)	Preop C/D	Preop Corneal Diameter (mm)	Preop No. of Medications
1	12	M	Bilateral	34	0.8	13	2
				38	0.9	13	2
2	5	M	Bilateral	42	0.8	13	2
				46	0.8	13.5	2
3	3	M	Bilateral	36	0.7	12.5	2
				40	0.8	13	2
4	48		Bilateral	28	0.8	13	2
				27	0.8	13	2
5	24	M	Unilateral	45	1.0	14	3
6	8	M	Unilateral	32	0.7	13	2
7	60	M	Bilateral	45	1.0	14.5	2
				46	1.0	15	2

ing, irritation, intraocular pressure >24 mm Hg under general anesthesia, and glaucomatous cupping at the optic disc. All patients were male with a mean age of 24.0±23.1 months (between 3 and 60 months) at the time of referral to our glaucoma unit. Five eyes of 3 patients had undergone unsuccessful glaucoma surgery, other than goniotomy, before their referral to our glaucoma clinic. Parents of all patients planning to take part in this study were informed about the surgical technique and gave informed consent before the operation.

Surgical Technique

All operations were performed by a single surgeon (SB) under general anesthesia. The operation began with a corneal stab incision made with a 20 g MVR (Visitec®, Sarasota, FL) knife in the inferotemporal quadrant. The anterior chamber maintainer (ACM) cannula (Visitec®) connected to an infusion bottle filled with BSS (Alcon®, Ft. Worth, TX) was inserted through this incision and the anterior chamber was deepened.

The endoscope device (Endooptics®, Little Silver, NJ shown in **Figure 1)** used in this study was composed of a control panel, console, video recorder, video monitor, and fiber optic probes measuring 19 and 20 g. Three beams—diode laser beam, xenon light source beam, and a viewing beam connected to a video camera and to the monitor—were integrated into those probes. We selected a 20 g probe for the goniotomy procedure because of its smaller diameter (external diameter measuring approximately 1 mm). The laser beam was not activated during the goniotomy proce-

dure, and only the lighting and viewing beams were used. In the double-port technique, a goniotomy cut was made by a special knife (Endooptics®) that could be integrated and inserted into the anterior chamber through the same corneal incision together with the probe, while a 20 g MVR blade (Visitec®) was inserted through a separate incision and used for goniotomy in the three-port technique. The anterior chamber maintainer cannula, 20 g MVR blade, 20 g endoscope probe, and special goniotomy knife are shown in **Figure 2.**

In the double-port technique, which was used in 6 eyes of 3 patients, a corneal stab incision was made in the superior quadrant and a 20 g endoscope (Endooptics®) probe together with the special goniotomy knife (Endooptics®) mounted on it were inserted into the anterior chamber through that incision **(Figure 3).** Goniotomy of the inferior 120° circumference of the angle was done under endoscopic visualization. The goniotomy incision used in our technique was a superficial cut applied to the trabecular meshwork and the procedure proceeded because the drop of the iris root and a whitish band were clearly seen on the endoscope's screen **(Figure 4).** As soon as the inferior quadrant angle was incised, the ACM cannula and the endoscope probe (goniotomy knife mounted on it) were exchanged. The anterior chamber maintainer cannula was inserted through the 12 o'clock incision while the goniotomy knife integrated with the endoscope's probe through the inferotemporal incision and goniotomy of the nasal angle were done.

In the three-port EG technique, three separate clear corneal stab incisions were used instead of two as in the double-port technique. The first incision was made in the inferotemporal quadrant and an ACM cannula was inserted. Then two stab incisions were made at the 1 and 11 o'clock positions. In this technique, a 20 g MVR knife (Visitec®)—instead of the special one designed by Endooptics®—was used for the goniotomy incision. The knife and endoscope probe were inserted through separate incisions and goniotomy of the inferior angle was performed **(Figures 5 and 6).** Then entry sites of the ACM cannula and MVR knife were exchanged and goniotomy of the nasal angle was done.

In all of the eyes, goniotomy of at least 240° circumference of the angle could be completed. During the operation, height of the infusion bottle was adjusted according to the anterior chamber depth, leakage through the incisions, and intraoperative hemorrhage. Pupils were constricted before surgery to prevent any potential damage to the crystalline lens and also at the end of the operation to keep the iris away from the goniotomy incision. The corneal incisions were sutured with 10-0 absorbable sutures at the end of the surgery.

Postoperatively, broad spectrum antibiotics and corticosteroid eye drops were instilled at least 5 times daily for a week. They were continued and stopped according to a tapered regimen depending on the postoperative inflammation of the individual patient.

Analysis of Follow-up Data

Surgical success was defined as follows: for complete success, intraocular pressure <17 mm Hg with-

out medications; qualified success, as intraocular pressure between 18 and 21 mm Hg without medications; and failure, as intraocular pressure ^22 mm Hg without medications. In all eyes with surgical failure and in some eyes (depending on optic nerve status) with qualified success, glaucoma medications were prescribed.

Intraocular pressure, number of glaucoma medications used, corneal diameter, and cup/disc ratios were recorded and compared for each eye at their referral prior to surgery and at the last control visit. Nonparametric Wilcoxons signed rank test was used for statistical comparisons. All of the statistical calculations were done by using SPSS for Windows Release 7.0 (SPSS Inc., Chicago, IL)

RESULTS

In the eyes of the patients studied, the mean preoperative intraocular pressure was 38.3 ±6.9 mm Hg range 27-46 mm Hg) and the average number of medications was 2.1 ± 0.3 (range 2-3). Average corneal diameter was measured as 13.5 ± 0.7 mm range 12.5-15 mm). Preoperatively, variable degrees of corneal clouding were present in all eyes, which prevented the surgeon from visualizing the anterior chamber angle with a surgical goniolens. Because of corneal clouding, preoperative retinoscopy could not be performed in any patient and only a gross estimation of glaucomatous cupping could be done. Average cup/disc ratio was found to be 0.84 ± 0.11 (range 0.7-1.0). All the patients had variable degrees of photophobia, epiphora, and/or blepharospasm, *3££2V££* p/ the young age, preoperative visual acuity testing could

be done in only 4 eyes of 2 patients whose ages were 48 and 60 months, respectively.

In both double- and three-port techniques, EG of at least 240° circumference of the anterior chamber angle could be done. Three separate entries were found to be advantageous over two because they gave the surgeon the opportunity of controlling the endoscope probe and goniotomy knife independently in the anterior chamber, which meant better visualization and surgical control. Intraoperative hemorrhage occurred in 9 eyes but was controlled by raising the infusion bottle and aspiration. Postoperatively, minor hyphema was noted in 4 eyes and Descemet breaks in the peripheral cornea in 2 eyes. There were no cases of iris or crystalline lens damage.

Patient data at final examination are shown in **Table 2.** At the end of the average follow up of 14.2 ± 9.7 months (range 6-32 months), mean intraocular pressure was found to be reduced to 17.6 ±2.8 mm Hg (range 14-24 mm Hg) with average 0.3 ± 0.5 medications (range 0-1). Those reductions obtained in intraocular pressure *(P* = 0.002) and number of glaucoma medications *(P* = 0.001) by EG surgery were found to be statistically significant **(Table 3).**

At the last visit, intraocular pressure was found to be ^ 17 mm Hg in 7 eyes (58.3% complete success), between 18 and 21 mm Hg in 3 eyes (25% qualified success), and ^ 22 mm Hg in 2 eyes (16.7% failure), without any glaucoma medications. The sum of complete and qualified success was 83.3%. At that time glaucoma medications had to be prescribed in 4 eyes

(33,3%), while the remaining 8 eyes (66.7%) where off any glaucoma medications.

Patient No.	Postop IOP (mm Hg)	Postop Corneal Diameter (mm)	Postop C/D	Postop No. of Medications	Surgical Success	Follow up (months)
			Table 2. Patient Data at Final Examination			
1	17	13	0.7	0	Complete success	32
	18	13.5	0.8	0	Qualified success	
2	17	13	0.7	0	Complete success	6
	24	14	0.8	1	Failure	
	16	12.5	0.6	0	Complete success	6
	18	13	0.7	0	Qualified success	
4	16	13	0.8	0	Complete success	20
	15	13	0.8	0	Complete success	
5	17	14	1.0	1	Complete success	12
	14	13	0.6	0	Complete success	12
7	22	14.5	1.0	1	Failure	9
	18	15	1.0	1	Qualified success	

A small but statistically significant reduction was evident in average cup/disc ratios from 0.84 ± 0.11 at referral to 0.79 ± 0.14 at last visit $(P = 0.014)$. However, there was no change in corneal diameter $(P = 0.157)$.

By the last visit, the eyes of all patient were transparent enough to permit accurate refraction and fundus examination, and were free from photophobia, epiphora, and blepharospasm.

DISCUSSION

Goniotomy operation had been the most widely used surgical option in the treatment of primary congenital glaucoma until the early 1980s. Although there were many studies reporting excellent outcomes in the literature,[6][12] it has begun to lose its popularity and other surgical options such as trabeculotomy with or without combined trabeculectomy has become the preferred approach among surgeons dealing with this rare disease.[13][17] The reason behind this preference has not been goniotomys ineffectiveness but rather its inconvenience. The absence of corneal transparency, which is very common in eyes with primary congenital glaucoma, is the most bothersome surgical obstacle for the surgeon preparing to perform goniotomy. This poor-quality angle visualization together with the fluctuation in the anterior chamber depth does not only lower the success, but raises the complication rate of the goniotomy operation as well. Otherwise, the goniotomy operation would be expected to yield equal or even greater pressure reductions than the one achieved by trabeculotomy, if proper solutions were found for those intraoperative problems. A greater proportion of the angle could be treated by goniotomy as compared with approximately 120° by the traditional trabeculotomy technique.

The endoscopic visualization and ACM system used in our study aimed to solve those two major intraoperative problems and to enable the surgeon to perform goniotomy in a recise and controlled fashion even

Table 3. Statistical Comparison of Patient Data			
	Preop	**Postop**	***P* Value**
IOP (mm Hg)	38.3 ± 6.9	17.6 ± 2.8	0.002*
No. of glaucoma medications	2.1 ± 0.3	0.3 ± 0.5	0.001 *
C/D ratio	0.84 ± 0.11	0.79 ± 0.14	0.014*
Corneal diameter (mm)	13.5 ± 0.7	13.5 ± 0.8	0.157
'Statistically significant			

in eyes with totally opaque corneas. In the traditional goniotomy technique, surgical goniolenses developed by Barkan, Koeppe, Worst, or Swan and Jacob were commonly used.[6][11] The view obtained by those lenses were in oblique orientation and the surgeon had to look at an oblique angle rather than the direct coaxial illumination and viewing system of the ophthalmic microscope.[6][8][11] This surgical technique was totally different from the one commonly used in ophthalmic microsurgery and usually caused orientation problems for the surgeon. Angle view obtained by those lenses could also get easily blurred even in eyes with slight corneal epithelial edema.

The use of an endoscope for goniotomy surgery was a relatively new idea and only animal studies and case reports were published in literature.[18][20] Their results were quite good and their authors pointed out that endoscopic goniotomy rather than trabeculotomy should be preferred in eyes with corneal opacification.

We performed endoscopic goniotomy by two different techniques. The double-port technique had the advantage of performing the whole surgery through two entry sites because in this technique the knife was integrated with the endoscopes probe. However, in the three-port system, three seperate incisions were needed through which the ACM cannula, endoscope probe, and goniotomy knife were introduced. Although in our current study at least 240° goniotomy could be done by both techniques, the use of three separate incisions provided clearer images of angle structures and more precise control of the goniotomy knife.

We also believed that maintenance of a deep and stable anterior chamber provided by the ACM system was extremely useful for the goniotomy of our study eyes with opaque corneas and made a great contribution to our successful results. In the very beginning of goniotomy surgery, no specific precautions were taken for the maintenance of a deep anterior chamber, but some infusion systems integrated with the goniotomy knife had to be developed after occurrence of serious complications such as lens or iris damage.[6][11] The ACM system has been reported as a very useful adjunct to the anterior segment surgical procedures in which a closed system and stable anterior chamber depth was necessary.[21][22] In our study, the use of an ACM system inserted through a separate incision was also found to be very convenient for the goniotomy procedure because pressure and depth of the anterior chamber could be maintained easily by using this approach.

For the maintenance of a deep and stable anterior chamber during goniotomy, some surgeons did prefer viscoelastic substances.[23][25] We also tried to perform EG under viscoelastics in some animal eyes before using the technique in human eyes, but the endoscopic images of the angle were not as clear as the ones we could get when we used ACM and BSS. Even tiny hemorrhages could make the procedure very difficult when it mixed with the viscoelastic. In such situations, the surgeon first had to evacuate the viscoelastic-blood mixture and fill the anterior chamber with viscoelastic again. In some instances of intraoperative hemorrhage, it would be impossible to gain a clear image of the angle again even after repeated evacuation procedures. The ACM system made the goniotomy procedure much easier because if any hemorrhage occurred during the procedure, it could be controlled by increasing the height of the infusion bottle so that the angle view always remained clear.

The potential complications of retained viscoelastics in the anterior chamber following anterior segment surgery were also well known for most ophthalmic surgeons. Increased incidence of postoperative inflammation together with pressure spikes could be sight threatening in those eyes with compromised optic nerves because it would be impossible and could be even dangerous to remove all viscoelastic from the anterior chamber. In our technique, we have tried to avoid such complications by using ACM and BSS. In our study, all of the eyes were found to be quiet with low levels of inflammation in the early postoperative period.

At the end of the average 13.8 months follow up, our total success rate was 83.3%, which means the proportion of eyes whose intraocular pressures were below 22 mm Hg without medication. It was comparable with or even better than other surgical options such as conventional trabeculotomy with or without trabeculectomy.[13][17] Because of limited access to the angle by the traditional trabeculotomy techniques, a newer trabeculotomy technique with a prolene suture was recently developed by Beck and Lynch.[26] The procedure was reported to give good results with minimal complications. It was not the aim of our current study to compare this modified trabeculotomy technique with our endoscopic goniotomy approach. However, we agree with Beck and Lynch that a more extensive proportion of the angle should be treated in a controlled and precise manner to gain a sustained and sufficient intraocular pressure reduction. Perhaps a controlled and randomized study comparing these two techniques will reveal which one is more efficient and safer in the management of congenital glaucoma. Although our study

sample was small and we did not have any control group, we have clearly demonstrated that endoscopic visualization together with the A C M system enabled us to perform goniotomy in a safe and efficient way in eyes with opaque corneas that were considered not to be eligible for the traditional goniotomy surgery. In the current study, endoscopic goniotomy, especially the three-port technique, is found to be an efficient and reliable way of performing angle incision surgery for treatment of primary congenital glaucoma, even in eyes with totally opaque corneas.

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