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Resident Surgical Training in Glaucoma

Steven J. Gedde, M.D. and Kateki Vinod, M.D.

Bascom Palmer Eye Institute, University of Miami, Miller School of Medicine, Miami, Florida

Abstract

Purpose of Review—This review provides an overview of the training of ophthalmology residents to perform glaucoma surgery.

Recent Findings—Data from the Accreditation Council for Graduate Medical Education indicate that the average number of glaucoma surgeries performed by graduating ophthalmology residents has remained stable over the past 5 years. However, a proportional increase in shunting procedures and decrease in filtering procedures has occurred during this time period. The existing medical literature has not identified any differences in the safety and efficacy of glaucoma procedures performed by residents compared with those performed by glaucoma specialists. A structured curriculum for glaucoma is designed to help residents transition from the wet lab to live surgery, and it serves to maximize resident learning and patient safety.

Summary—Tube shunts are being used with greater frequency in the surgical management of glaucoma as an alternative to trabeculectomy, and this shift in practice patterns is reflected in the surgical experience of ophthalmology residents. Patients should be reassured by the outcomes of resident-performed glaucoma surgery, which compare favorably with those reported by experienced glaucoma surgeons. A structured curriculum can assist in introducing residents to glaucoma surgery.

Keywords

Glaucoma surgery; training; ophthalmology residency; surgical curriculum

INTRODUCTION

Residents in ophthalmology are expected to develop competency in performing a broad range of ophthalmic procedures. Glaucoma surgery is one of the core areas evaluated by the Accreditation Council for Graduate Medical Education (ACGME) with the Resident Case Log System, the online system used to monitor resident surgical experience [1]. Surgical training involves an understanding of the preoperative assessment and postoperative management of patients. This is particularly important in glaucoma surgery because the surgical indications are less standardized and the postoperative care is more complex

Corresponding author: Steven J. Gedde, M.D., Bascom Palmer Eye Institute, 900 N.W. 17th Street, Miami, Florida 33136. Telephone: 305-326-6435. Fax: 305-326-6478. sgedde@med.miami.edu.

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CONFLICTS OF INTEREST

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compared with many other ocular procedures. Technical skills may be acquired while observing or assisting in surgery. However, the greatest learning occurs when the resident is operating as the primary surgeon.

Several issues relating to resident glaucoma surgery should be considered. Ethical concerns exist about a novice surgeon performing a procedure in a live patient which has not yet been mastered. Many glaucoma procedures have a narrow tolerance for intraoperative error, and even seemingly small mistakes in surgical judgment or technique may result in irreversible adverse events. There are added costs associated with the inherent inefficiencies of resident-performed surgery. Discussions among educators are ongoing regarding the minimum number of cases needed for residents to gain surgical competence. The inclusion of recently developed glaucoma procedures into residency training has also been debated.

The purpose of this review is to describe the glaucoma surgical experience currently provided by ophthalmology residency programs in the United States. We discuss recent studies evaluating the outcomes of glaucoma surgery performed by residents. We present elements of a structured curriculum for glaucoma surgery, which seek to optimize resident learning and patient safety.

RESIDENT EXPERIENCE IN GLAUCOMA SURGERY

Data on the operative experience of ophthalmology residents demonstrate some interesting trends in glaucoma surgery. The ACGME requires that each resident perform a minimum of 5 glaucoma filtering/shunting procedures as primary surgeon before graduation [1]. Figure 1 shows the number of filtering and shunting procedures performed with the resident as primary surgeon from 2009 to 2014. The average number of incisional glaucoma surgeries during training has remained fairly stable at approximately 10 cases per resident. However, there has been a steady decrease in the average number of filtering procedures and a concurrent increase in the average number of shunting procedures.

Chadha and associates [2•] noted that the growing use of tube shunts as an alternative to trabeculectomy in residency training mirrors an observed trend among Medicare beneficiaries [3••]. The authors attributed the shift in glaucoma surgical practice patterns to influence from the Tube Versus Trabeculectomy (TVT) Study, a multicenter randomized clinical trial comparing the safety and efficacy of tube shunt implantation and trabeculectomy with mitomycin C (MMC) in eyes with prior ocular surgery [4–6]. They expressed concern that residents may be inadequately trained to perform trabeculectomy and manage patients who have undergone this procedure [2•]. The ACGME emphasizes that surgical numbers are only an indicator of resident experience and do not directly translate into proficiency [1]. It is the responsibility of training programs to ultimately judge the surgical competence of each resident.

A survey of ophthalmology residency program directors by Golden and colleagues [7] provides further insights into resident glaucoma surgical training in the United States. A majority of ophthalmology residents (72%) began observing glaucoma surgery during the first year of residency, and most started assisting in glaucoma surgery as first-year (40%) or

second-year (48%) residents. Initial exposure to glaucoma surgery as the primary surgeon generally occurred during the third year of residency (67%). Fellowship-trained glaucoma surgeons were responsible for teaching residents most or all glaucoma surgery at 84% of residency programs. Multiple staff surgeons were responsible for teaching glaucoma surgery at 75% of programs, allowing exposure to more than one surgical technique.

STUDIES OF RESIDENT GLAUCOMA SURGERY

Several retrospective studies have evaluated outcomes of resident glaucoma surgery [8–10•, 11–13] and are summarized in Table 1. Chen and coworkers [8] analyzed the results of trabeculectomy performed by residents at the University of California, San Francisco. Surgical success (IOP $\leq$ 21 mm Hg or decreased by $\geq$ 25%, IOP $>$ 5 mm Hg, no additional glaucoma surgery) was observed in 84% of eyes after a mean follow-up of 28.9 months. Desai and associates [9] reported a success rate of 78% after a mean follow-up of 34.7 months for resident-performed Ahmed glaucoma valve implantation from the same training program and applying a similar definition of success. In their investigation of trabeculectomy with MMC performed by residents at the University of California, Los Angeles, Kwong and colleagues [10•] found a cumulative probability of surgical success (IOP $\leq$ 15 mm Hg or $\geq$ 15% reduction, no additional glaucoma surgery, no loss of light perception vision) of 65.0% at 5 years.

Studies have retrospectively compared different glaucoma procedures performed by residents at the same training institution. Connor and coworkers [11] evaluated trabeculectomy with MMC and tube shunt surgery done by residents at the University of Florida. The probability of failure (IOP $>$ 21 mm Hg or reduced $<$ 20%, IOP $<$ 5 mm Hg, glaucoma reoperation, no light perception vision) at 1 year was 38% in the trabeculectomy group and 17% in the tube shunt group ($p < 0.05$). Complications were observed in 30% of eyes after trabeculectomy and 10% of eyes after tube shunt surgery. Seider and associates [12] compared trabeculectomy and Ex-PRESS shunt implantation performed by residents at the University of California, San Francisco. The rates of surgical success (IOP 6–21 mm Hg, no glaucoma reoperation) at 1 year were 85% in the trabeculectomy group and 91% in the Ex-PRESS group. Complication rates were 57.9% in the trabeculectomy group and 61.1% in the Ex-PRESS group ($p = 0.68$).

Retrospective studies have directly compared glaucoma surgery performed by residents to those performed by supervising attending surgeons. Morrell and coworkers [13] investigated trabeculectomies performed by senior surgeons and surgeons-in-training at the Birmingham and Midland Eye Hospital in the United Kingdom. Surgical success (IOP $<$ 21 mm Hg without progression) was achieved in 85.1% of resident-performed cases and 92.0% of cases by senior surgeons ($p = 0.96$). In the previously discussed study by Kwong and colleagues [10•], a subset of trabeculectomies with MMC performed by residents at the University of California, Los Angeles were case-matched with procedures by attending glaucoma specialists at the Jules Stein Eye Institute. The cumulative probability of success was 62.1% and 65.5% at 5 years for the resident and attending cases, respectively ($p > 0.05$).

STRUCTURED CURRICULUM FOR GLAUCOMA SURGERY

Many ophthalmology residency programs have successfully implemented a structured curriculum to transition residents into cataract surgery. Rogers and associates [14] showed that institution of a cataract surgical curriculum significantly reduced the rate of surgical complications in resident cataract surgery at the University of Iowa. A similar approach in curriculum development for cataract surgery may be applied in resident glaucoma surgery.

Shen and colleagues [15•] described the introduction of a glaucoma surgical curriculum for residents at the Massachusetts Eye and Ear Infirmary. The curriculum consisted of preoperative training, intraoperative teaching, and postoperative feedback. Glaucoma surgical volume increased, a self-assessment survey showed improvement in suturing, and a standardized assessment of surgical skills demonstrated an improvement in handling adverse events following implementation of the curriculum.

Table 2 lists elements of a structured curriculum for glaucoma surgery that was developed at the Bascom Palmer Eye Institute.

Written goals and objectives

The ACGME mandates that overall educational goals for the residency program, and specific goals and objectives for every rotation at each level of training must be provided to residents in a written or electronic format [1]. The initial exposure to glaucoma surgery at the Bascom Palmer Eye Institute occurs during the glaucoma rotation in the second year of residency. The goals and objectives are reviewed with the resident at the start of the rotation, including a list of cognitive and technical skills that the resident is expected to acquire. Examples of cognitive skills include, “to describe the basic steps involved in trabeculectomy and tube shunt surgery” and “to describe the postoperative complications seen after glaucoma surgery.” Examples of technical skills include, “to perform laser trabeculoplasty” and “to perform trabeculectomy.”

Pre-test/post-test

A glaucoma quiz is administered to the resident at the beginning of the rotation. Table 3 shows sample questions related to glaucoma surgery that are incorporated into the quiz. Additional questions on glaucoma diagnosis, epidemiology, clinical trials, medical management, and laser therapy are included. The quiz is readministered at the end of the rotation with the goal of demonstrating improvement in glaucoma knowledge.

Assigned reading list

An assigned reading list is provided to the resident at the start of the rotation consisting of selected peer-reviewed papers and chapters from glaucoma textbooks. Surgical atlases with abundant illustrations are particularly instructive to support the written descriptions of glaucoma procedures.

Review of surgical videos

Surgical videos of procedures to be performed during the rotation are reviewed with the resident, including trabeculectomy and tube shunt surgery. Each step of the procedure is discussed in detail with a member of the glaucoma faculty.

Mandatory wet lab

The ACGME requires that all ophthalmology programs have a surgical skills development resource (wet lab and/or virtual reality simulator) [1]. Human cadaver eyes are readily available to our residents from the Florida Lions Eye Bank and are used to practice surgical techniques in the wet lab. Table 4 presents a mandatory wet lab checklist that must be completed by the resident prior to performing surgery on a live patient. The checklist assesses knowledge of the common ophthalmic instruments used in glaucoma surgery and establishes proficiency of various steps in glaucoma procedures.

Virtual reality simulators have become available to many ophthalmology residency programs to assist in surgical training [16]. These simulators have generally focused on cataract and retinal surgery, but basic modules allow residents to become more comfortable working under an operating microscope. Additionally, simulation models have been developed for various glaucoma procedures, including goniotomy [17, 18], trabeculectomy [19], and ab interno trabeculectomy [20].

Assisting in surgery

The resident assists and observes glaucoma surgery prior to operating as the primary surgeon.

Standardized evaluation of surgical skills

Several standardized instruments have been developed to evaluate resident surgical skills [21–24]. The Global Rating Assessment of Skills in Intraocular Surgery (GRASIS) is a 1-page evaluation form that has been validated and may be used for any intraocular procedure [22]. This surgical assessment tool consists of 10 components of operative skills graded on a 5-point Likert scale and may be easily adapted to glaucoma surgery.

Feedback

Formative feedback is “on-the-spot” feedback that occurs during the learning process (e.g., during a surgical case or immediately after). Summative feedback is provided at the end of a learning period (e.g., end of rotation). Reinforcing feedback is especially valuable for novice learners, while advanced learners benefit more from corrective feedback. Feedback is critical in promoting continued improvement of residents and the residency program.

Milestone assessment

The ACGME launched the Next Accreditation System (NAS) in ophthalmology in July 2014. This extensive revision of the process by which residency programs are accredited has significantly impacted ophthalmology residency training [25]. An important component of the NAS is milestone assessment. “Milestones” are observable developmental steps that

describe a trajectory of progression from novice (entering resident) to proficient (graduating resident). Faculty members report resident progress to a Clinical Competency Committee, and a formal milestone assessment is provided to the ACGME semiannually. Milestones have been established for glaucoma surgery as a product of the Ophthalmology Milestone Project, a collaborative effort between the ACGME and American Board of Ophthalmology [1].

CONCLUSIONS

Glaucoma surgical training is an important part of the overall ophthalmology resident experience, and the ACGME mandates that a minimum number of glaucoma procedures be performed with the resident as primary surgeon [1]. These cases are generally done during the final year of residency, and multiple faculty with glaucoma subspecialty training provide surgical instruction [7]. The increase in the number of shunting procedures and concomitant decrease in filtering procedures among resident graduates parallels the surgical trend observed in Medicare beneficiaries [2•, 3••]. Despite concerns about the proficiency of novice surgeons, retrospective studies have reported similar outcomes following glaucoma surgery performed by residents and experienced glaucoma specialists [8–10•, 11–13]. Implementation of a structured curriculum for glaucoma surgery helps residents transition to surgery on a live patient, and it is expected to maximize resident learning and patient safety.

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KEY POINTS

- A recent increase in shunting procedures and decrease in filtering procedures by graduating ophthalmology residents parallels the surgical trend observed among Medicare beneficiaries.
- The outcomes of glaucoma surgery performed by residents and glaucoma specialists is similar in retrospective comparative studies.
- A structured curriculum can assist residents' transition from the wet lab to live glaucoma surgery.

Figure 1. Number of glaucoma procedures with resident as primary surgeon. The box plots show mean (diamonds), median (dark horizontal lines), 30/70 percentiles (boxes), and 10/90 percentiles (vertical whiskers).

Table 1

Studies of Resident Glaucoma Surgery

Author, year	Procedure	N, surgeon	IOP (mm Hg)		Success rate	Complication rate	Mean follow-up (months)
			Preop	Postop			
Chan et al, 2007 [8]	Trabeculectomy	50, resident	23.3	11.3	87%	NR	28.9
Desai et al, 2010 [9]	Ahmed	50, resident	30.8	15.3	78%	44.2%	34.7
Kwong et al, 2014 [10]	Trabeculectomy	85, resident	22.5	11.8	65.0%	9.4%	45.2
		29, attending	19.8	10.8	65.5%	6.9%	52.7
Connor et al, 2010 [11]	Trabeculectomy Tube shunt	93, resident	19.8	12.1	62%	30%	NR
		60, resident	29.3	13.0	83%	10%	
Seider et al, 2012 [12]	Trabeculectomy Ex-PRESS	57, resident	20.3	12.9	85%	57.9%	NR
		36, resident	20.1	12.7	91%	61.1%	
Morrell et al, 1989 [13]	Trabeculectomy	47, resident	NR	NR	85.1%	NR	37.2
		50, attending			92.0%		48.5

N = number of eyes; NR = not reported

Table 2

Elements of a Structured Curriculum for Glaucoma Surgery

•	Written goals and objectives
•	Pre-test/post-test
•	Assigned reading list
•	Review of surgical videos
•	Mandatory wet lab
•	Assisting in surgery
•	Standardized evaluation of surgical skills
•	Feedback
•	Milestone assessment

Table 3**Sample Questions Related to Glaucoma Surgery**

1	What is the average scleral thickness?
a.	0.5 mm
b.	1.0 mm
c.	1.5 mm
d.	2.0 mm
2	Which is the correct order of steps for trabeculectomy?
a.	Conjunctival flap dissection, scleral flap dissection, sclerotomy, iridectomy, paracentesis, suture scleral flap, close conjunctiva
b.	Conjunctival flap dissection, sclerotomy, paracentesis, scleral flap dissection, iridectomy, suture scleral flap, close conjunctiva
c.	Conjunctival flap dissection, scleral flap dissection, paracentesis, sclerotomy, iridectomy, suture scleral flap, close conjunctiva
d.	Conjunctival flap dissection, sclerotomy, iridectomy, paracentesis, scleral flap dissection, suture scleral flap, close conjunctiva
3	Which of the following is a valved aqueous shunt?
a.	Ahmed
b.	Baerveldt
c.	Molteno
d.	Schocket
4	The tube of an aqueous shunt is inserted through what sized needle track?
a.	21-gauge
b.	23-gauge
c.	25-gauge
d.	30-gauge
5	Which of the following is a contraindication to trabeculectomy surgery?
a.	Elevated episcleral venous pressure
b.	Intolerance to glaucoma medications
c.	Pseudoexfoliation glaucoma
d.	Superior conjunctival scarring
6	Where is the incision made when dissecting a fornix-based conjunctival flap?
a.	Clear cornea
b.	Limbus
c.	3.5 mm posterior to limbus
d.	10 mm posterior to limbus
7	Where is the sclera thinnest?
a.	Equator
b.	Limbus
c.	Rectus muscle insertion
d.	Vortex veins
8	Which quadrant is most commonly used for implantation of an aqueous shunt?
a.	Inferonasal
b.	Inferotemporal

- c. Superonasal
d. Superotemporal
- 9 Which is the correct order of steps in Baerveldt implantation?
- a. Conjunctival flap dissection, attachment of end plate, tube fenestration, ligation of tube, tube insertion, patch graft placement, conjunctival closure
b. Conjunctival flap dissection, attachment of end plate, ligation of tube, tube fenestration, tube insertion, patch graft placement, conjunctival closure
c. Conjunctival flap dissection, tube fenestration, ligation of tube, attachment of end plate, tube insertion, patch graft placement, conjunctival closure
d. Conjunctival flap dissection, attachment of end plate, tube insertion, tube fenestration, ligation of tube, patch graft placement, conjunctival closure
- 10 What suture is used to close the scleral flap in trabeculectomy surgery?
- a. 3-0 gut
b. 7-0 vicryl
c. 9-0 prolene
d. 10-0 nylon

Answers: 1 = b; 2 = c; 3 = a; 4 = b; 5 = d; 6 = b; 7 = c; 8 = d; 9 = b; 10 = d

Table 4**Mandatory Wet Lab Checklist**

☐ Correctly identifies surgical instruments
<ul style="list-style-type: none">• Scissors (blunt Westcott scissors, de Wecker scissors)• Forceps (Castroviejo 0.12 forceps, Colibri forceps, serrated conjunctival forceps, straight tying forceps)• Blades (15° microsurgical blade, #69 Beaver blade)• Needle holder• Kelly punch
☐ Paracentesis
<ul style="list-style-type: none">• Proper placement and length• Uses second instrument to stabilize globe
☐ Scleral flap dissection
<ul style="list-style-type: none">• Smooth edges• Appropriate flap thickness
☐ Removal of inner block
<ul style="list-style-type: none">• Correct entry into anterior chamber• Creation of proper-sized sclerostomy
☐ Suture scleral flap
<ul style="list-style-type: none">• Needle pass at correct depth• Ties with appropriate tension