Trabecular Surgery for Glaucoma

Brian Francis, MD

Doheny Eye Institute
Keck School of Medicine
University of Southern California
Trabecular Surgery

Thanks to:
Douglas Johnson, MD, Mayo Clinic
Don Minckler, MD, UC Irvine
Rick Lewis, MD, Sacramento, CA
Michael Berlin, MD, Beverly Hills, CA
Glaucoma Surgery

- **Inflow procedures**
- **Outflow procedures**
  - External filtering surgery
  - Internal filtering surgery
    - Ab interno approach
      - Goniotomy
      - Trabectome, ELT, trabecular stent
    - Ab externo approach
      - Trabeculotomy
      - Viscocanalostomy, Canaloplasty
Aqueous Inflow Surgery

- Severe inflammation
- Widespread tissue damage
- Hypotony and phthisis

Transscleral CP

Endoscopic CP
External Filtering Surgery

- Bleb leaks, tube exposures, infections
- Hypotony, choroidals, maculopathy

Leaking bleb

Infected bleb
Inflow & External Filtering Surgeries

- Both are non-physiologic

Leaking bleb

ECP
Trabecular Meshwork

clinical: gonioscopic view

SEM
Trabecular Meshwork: *Human Eye*

light microscope: *H&E*  SEM
POAG: is TM the site of resistance?

Yes: demonstrated by Grant in 1963

**trabeculotomy:**
- Normal eye: eliminates 50% of R
- GL eye: eliminates *all* of abnl R

Note: sclera has 50% of normal R:
- IOP will not drop to 0 mmHg

Anterior chamber
GL 18LN
Revisiting Trabecular Surgery

- Goniotomy
- Trabeculotomy: ab externo, ab interno
- Non-penetrating deep sclerectomy
- Excimer laser trabeculoplasty
- Schlemm’s canal stenting procedures
- Canaloplasty
- Ab interno trabeculectomy: Trabectome
Goniotomy – Effective only in Children

- View of Angle/Meshwork through surgical lens

Trabeculotomy: Children When Visualization Poor

- Main difficulty is identifying Schlemm’s
- Possible conversion to trabeculectomy
- Circumferential suture rupture done by some

Trabeculotomy in Adults:
*Swan Trabectome*

Trabeculotomy Ab Interno in Adults

Ab interno Trabeculotomy with Swan Trabectome*

- Randomized trial of ab interno trabeculotomy (n = 16) to trabeculectomy with MMC-trabeculectomy (n = 16)
- Adult open-angle glaucomas
- Matched for age, IOP, duration of glaucoma, beta-blocker and parasympathomimetic use.
- 87.5% of trabeculotomy eyes and 81.25% of MMC-trabeculectomy eyes had IOPs ≤ 14mmHg at two years follow-up.
- Complications
  - Trabeculotomy = hyphema in 37.5% (6/16).
  - Trabeculectomy with MMC = hypotony maculopathy in 6.25% (1/16), and blebitis in 12.5% (2/16).
Ab externo trabeculotomy with Nagata trabectome*

- Randomized trial of ab externo trabeculotomy (n = 44) to trabeculectomy with MMC (n = 35) in adult open-angle glaucoma.
- No statistically significant differences in IOP outcomes at one year.
- The probability of successful IOP outcome for trabeculotomy (IOP < 21 on or off medications) was .8644 [86%] compared to trabeculectomy with MMC at .8432 [84%].

Complications

- Trabeculectomy: epithelial damage 57% (20/35), bleb leaks 14% (5/35), hypotony [IOP < 5 X 1 week] 37% (13/35), shallow anterior chambers 46% (16/35), serous detachments 29% (10/35), and fibrin reactions 11% (4/35) were statistically significantly higher in trabeculectomy eyes.
- Only hyphema was more common in trabeculotomy eyes 93% (41/44) but also occurred in trabeculectomy eyes 46% (14/35).

DS Viscocanalostomy

Procedure (Stegmann, 1999)

- Conjunctival flap (limbus or fornix)
- Superficial scleral flap (1/3)
- Deep scleral flap (90%) exposing SC
- Paracentesis $\Rightarrow$ IOP to zero
- Anterior exposure of DM
- Viscoelastic injected into SC
- Deep scleral flap removed
- Scleral flap tightly sutured
- Viscoelastic injected into scleral lake
**DS Viscocanalostomy**

Mechanism of action: theoretical

- Bypass juxtacanalicular tissue
- Aqueous flows through DM
- JC TM, SC inner wall intact
- Aqueous redirected into SC
- Tight scleral flap
- No bleb formation
- Visco prevents fibrinogen migration
I-View Confocal Imaging System
(pre-op VC Schlemm’s Canal)
I-View: *(post-op Viscocanalostomy)*

- I-View: high resolution ultrasound imaging system with center frequency of about 80 MHz.
Viscocanalostomy: ruptures canal wall and JCT
Newer Approaches to Angle Surgery

- Excimer Laser Trabeculoplasty
- Canaloplasty
- Schlemm’s canal stents
- Trabeculectomy Ab interno: Trabectome
TM showing collector channel
2 collector channels

frontal section: CC are \(~0.5\) mm apart

sclera

CC

SC

TM

CC

SC

100 \(\mu m\)
Removal of TM to view outer wall of Schlemm’s canal
Scanning EM after removal of TM: outer wall of canal visible

cornea

CC ostia

ant TM

cut

canal

dissection of TM by hand

500 μm
Canaloplasty

Fiber optic cannula
Canaloplasty: Procedure

- External exposure of SC
- Fiber optic tube threaded through SC 360°
- Tube tied to prolene suture
- Suture is pulled out through AC
- Trabeculotomy ab externo
Trabecular Stents

Glaukos: Titanium drain bypassing TM

stent from Glaukos Corporation
Franz Grehn, MD (PI)
Würzburg, Germany
Trabecular Stents

iStents in TM of cultured eye seen from inside of eye

Glaubkos Corp:
Laguna Hills CA
iStent in lumen of canal

normal TM

stent in TM
Titanium stents placed into Schlemm’s lower IOP in organ-cultured human anterior segments.

The first shunt has the most effect. IOPs were lowered from $21.4 \pm 3.8$ mmHg to $12.4 \pm 4.2$ mmHg.

Successive addition of shunts further lowered IOP and complete removal of the meshwork between shunts lowered IOP to $6.3 \pm 3.2$ mmHg.

Trabecular Stents
GMP implant
Trabeculectomy ab interno:

Trabectome - a true trabeculectomy
Schlemm’s Canal

Insulated footplate acts as a guide within Schlemm’s Canal
Ab interno trabeculectomy: development of a novel device (Trabectome™) and surgery for open-angle glaucoma


- In vitro donor cornea scleral rims
- Trabectome performed at various power settings
- Histopathology studied
A [control]; B [goniotomy]; C: confocal goniotomy; D: Trabectome™
Trabectome
Trabectome Study:
Patient Demographics

- 49 patients (24 male & 25 female Hispanic/White) age 63 ± 11 years; failing medical therapy, healthy, POAG & sub-types:
  - POAG 38
  - Pseudoexfoliation: 8
  - Pigment Dispersion: 2
  - Steroid-induced: 1
  - Previous trabeculectomy 1
- VFD/Disc minimal damage 18; moderate - advanced 31
- Initial lens status
  - Phakic without cataract: 34
  - Pseudophakic: 3
  - With mild cataract: 12
- Mean Medications/patient down from 1.4 to 0.4 postoperatively
Trabectome Complications: (49 patients)

- Intraoperative blood reflux when instrument removed in majority:
- Hyphema cleared by $6.4 + 4.1$ days
  - 20% hyphema largest in this series
  - Minimized by wound suture/air tamponade/Iopidine
  - 2% Pilocarpine pre-op & 2–6 weeks post-op
- Corneal injuries: 6/49 (12.2%)
  - Epithelial defect: 3/49 (6%)
  - Decemet’s hemorrhage: 1/49 (2%)
  - Focal Decemet’s scroll/detach: 1/49 (2%)
  - Persisting Decemet’s injury: 1/49 (2%)
- Partial PAS/goniosynechiae: 14/49 (28.5%)
- IOP spike
Complications of trabeculectomy *Not* seen in this series to date:

- Flat or Shallow Anterior Chambers
- Persisting corneal edema
- Iris Injury
- Hypotony or hypotony maculopathy
- Infection
- Cataract Progression
- Wound Leak
- Bleb formation
- Choroidal Effusion; choroidal hemorrhage
- Visual Acuity Decrease (>2 Lines)
IOP Outcomes

- **Success:**
  - < 30% Pressure Drop: 6/49 (12%)
  - > 30% Pressure Drop: 43/49 (88%)
  - % IOP decrease (all 49 Patients)
    - Mean: = 44% ± 13%
    - Range: 4% - 68%
  - IOP < 21 with or without medications = 44/49 (90%)

- **Failures:** 5/49 = 10%
  (IOP > 21 mmHg with/without medications or additional surgery)
  - 1 (unsutured) re-bleed after trauma at 1 month; trabeculectomy
  - 2 refusals to resume medication at post op IOPs = 24 & 22
    (Pre op IOPs 34 & 24)
    - The patient with 24 mmHg post Op has post op IOP of 16 on meds
  - 2 on post op meds with IOPs > 21 mmHg
    - (22 & 26 mmHg) (Pre op = 30 mmHg on both)
Trabectome

Pre-op IOP = 28.4 ± 4.4 mmHg (n=49)
24 months post-op IOP = 15.8 ± 2.3 mmHg (n=19)

Overall success to date: (IOP < 21 on/off medications) = 90% [44/49]
(5 failures: 1 subsequent trabeculectomy; 2 refused to resume medications; 2 with IOP > 21 on medications)
Latest Results June 2007
## Trabectome: Clinical Results

### Demographics

Demographics of patients included in this update summary, including the number of combined cataract and Trabectome® cases to date.

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Number</th>
<th>Percentage</th>
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<tr>
<td>AGE</td>
<td>434</td>
<td>100%</td>
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<tr>
<td>Mean</td>
<td>70</td>
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<td>STD</td>
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<tr>
<td>Maximum</td>
<td>93</td>
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<td>RACE</td>
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<td>African American</td>
<td>21</td>
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<td>Asian</td>
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<tr>
<td>Caucasian</td>
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<td>Hispanic</td>
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<td>Other</td>
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<td>DIAGNOSIS</td>
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<tr>
<td>POAG</td>
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<td>Pseudoexfoliation (PXE)</td>
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<tr>
<td>JRA</td>
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<tr>
<td>Other</td>
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<tr>
<td>Moderate</td>
<td>175</td>
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<td>Advanced</td>
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<td>MD/Other</td>
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<td>DISC C/D (if known)</td>
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<tr>
<td>&gt;0.4 - 0.6</td>
<td>92</td>
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<tr>
<td>0.7 - 0.8</td>
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<td>&gt;0.8</td>
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<td>LENS STATUS</td>
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<td>Suecophakic</td>
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<tr>
<td>IV</td>
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Combined cataract extraction and Trabectome procedures
### Trabectome: Clinical Results Summary

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<th>Pre-op IOP (w or w/o Rx)</th>
<th>1 day</th>
<th>1 Week</th>
<th>2 Weeks</th>
<th>1 month</th>
<th>2 months</th>
<th>3 months</th>
<th>4 months</th>
<th>5 months</th>
<th>6 months</th>
<th>7 months</th>
<th>8 months</th>
<th>9 months</th>
<th>10 months</th>
<th>11 months</th>
<th>12 months</th>
<th>13 months</th>
<th>18 months</th>
<th>21 months</th>
<th>24 months</th>
<th>30 months</th>
<th>36 months</th>
<th>40 months</th>
<th>44 Months</th>
<th>48 Months</th>
<th>52 Months</th>
<th>TOTAL MEAN</th>
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<tr>
<td>Pre-op IOP (w or w/o Rx)</td>
<td>24</td>
<td>8</td>
<td>0%</td>
<td>434</td>
<td>342</td>
<td>266</td>
<td>159</td>
<td>227</td>
<td>186</td>
<td>120</td>
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<td>69</td>
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<td>36</td>
<td>26</td>
<td>43</td>
<td>27</td>
<td>26</td>
<td>20</td>
<td>25</td>
<td>16</td>
<td>16</td>
<td>9</td>
<td>4</td>
<td>5</td>
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Trabectome: Clinical Results Summary
Trabectome: Clinical Results
Summary
Ab Interno Trabeculectomy with Trabectome

- Adults with open angle and clear gonioscopic view
- IOP goal range of 14 – 17 mmHg
- Safer; simpler follow-up; low complication rates compared to trabeculectomy
- Fits into therapy spectrum before trabeculectomy or other surgical filtering procedures
- Does not preclude subsequent surgery (spares conjunctiva)
- May be effective after failed external filtering surgery
Glaucoma Trabecular Surgery: Conclusions

• Re-establishes aqueous outflow by removing site of most resistance
• Reduced risk of hypotony, infection
• Limited to open angle glaucoma
• Good visualization of angle structures
• Limited to IOP in mid-teens
• Role in primary glaucoma surgical treatment
  • Developing countries