Trabectome Surgery: Techniques and New Indications

Nils Loewen, MD, PhD
Director, Glaucoma and Cataract Service
Associate Professor of Ophthalmology
University of Pittsburgh School of Medicine
disclosures: *NL - trabectome trainer*
Overview

1) Background
2) Technique + Postop Care
3) Outcomes
4) Case Presentations
5) Wet Lab
TRABECTOME
TECHNIQUE + POSTOP CARE
Overview

MIGS vs Trabs/Tubes?

Trabectome Technique + Postop Care
MINIMALLY INVASIVE GLAUCOMA SURGERIES (MIGS) VS TRABS/TUBES
Problems with Hardware and MMC
240° versus 60°

Single access point devices:
- achieve only 2 clock hours of outflow segment access.

Canalography courtesy of UPMC’s Glaucoma Imaging Group

Outflow Tract Anatomy

sagittal view

frontal view

schematic view
Trabectome Surgical System

new, tapered sleeve
Plasma Surgery: Bipolar 550 kHz Ablation of Trabecular Meshwork

- selective removal of **primary pathology**
- 200 micron plasma, pico-lightning
- no heat transfer, protective footplate

1.2°C

Very hot
Very short (1ms)
Low duty cycle

Continuous aspiration

Microscopic images of eye drainage tissue before and after Trabectome
proximity to anterior and posterior lips may explain high failure rate of *goniotomy* in adults
Challenges with Microstents

Fibrosis + Compression of Collector Channels

courtesy of Ivantis Inc., Irvine, CA
Angle Surgery: What Glaucomas?

- POAG
- Pseudoexfoliation
- Steroid induced
- Anti-VEGF agents-induced
- Acute angle closure
- Chronic angle closure
- Low pressure

Success 90-70%

TM pathology

Working collector drainage system necessary. Currently no function test available.
5 Year Complications

**MIGS**
- early 10 mmHg IOP elevation that resolves
  - trabectome: 3-10%
- hyphema that resolves
  - more Schlemm's canal access = more hyphema
  - trabectome > hydrus > iStent

**Trab/Tube (TVT Study)**
- "manipulation needed"
  - trabs: 74%
  - tubes: 27%
- early + late, vision threatening
  - trabs: 39 + 38 = 77%
  - tubes: 22 + 36 = 58%
Cost Effective Treatment Algorithm


BAT 20/50, wants to improve vision, has OHTN to advanced glaucoma

\[\text{CEIOL + trabectome} \]

\[\text{toric lens} \]

\[\text{bypass surgery (tube, trab, suprachoroidal devices)} \]

\[\downarrow\]

\[\text{SLT} \]

\[\downarrow\]

\[\text{PGAs + CAIs} \]
TRAECTOME
TECHNIQUE + POSTOP CARE
Key Surgical Steps

1. Visualization
   - excellent microscope (xenon, large tilt)
   - no visco at start
   - hypotony, identify

1. Technique
   - anterior, flared incision
   - no outward push
   - near 180° ablation

1. Reducing hyphema
   - viscoelastic tamponade: after ablation + after phaco
   - pressurize well
Visualization
xenon light, large tilt
Large Tilt, Xenon Light
Impact of Microscope Quality

- high end, xenon light
- large tilt

- insufficient tilt: requires patient rotation
- yellow light: hard to see lacy tissue

STOP
No Viscoelastic Prior to Trabectome

Because viscoelastic:

- traps plasma gas bubbles
- creates blurr from density interfaces
- makes it harder to induce hypotony to identify Schlemm's canal
SURGICAL STEPS
2 mm Anterior, Flared Incision

- extend reach, no striae
- prevent iris prolapse
Induce Hypotony to Identify TM

gape incision

sc
Easier Engagement Towards Left

- Tip parallel
  - Hard to engage
- Pointed at TM
  - Easy to engage
1. just anterior to spur: engage pointing up

2. advance strictly parallel, no outward push

TM removal: careful with outward push as if you were peeling an epiretinal membrane
Engaging the TM
180° Ablation

tilt to brow

tilt to cheek

insertion

left

right

gonio: heel up
Larger Arc = More Collectors

- Marginally significant correlation between:
  - Ablation arc size vs final IOP ($P=0.06$)
  - Ablation arc size vs final number of medications ($P=0.07$)

$$IOP = 20.5 - 0.053(Arc \ size)$$

$n=29; \ R=0.351; \ P=0.06$

A. Sit, 2011
After Trabectome

1. **Tamponade** trabectome ablation with **DisCoVisc**
2. Enlarge same incision with keratome heel down (self sealing)
3. Phaco
4. **Tamponade** ablation again with **DisCoVisc**
5. IOL (+ CTR for torics if phacodonesis)
6. **Leave visco** in distal half of AC (no hyphema)
Incision Enlargement for CEIOL
Post-Op

- "Changing blurriness for days“, blurry = outflow system present!
- POV 1 day, 1 week, month 1, 2, 3
  - Pilo QID x 1 month, TID 1 month, BID 1 month
  - Pred Forte QID tapered one drop per week
  - discontinue some glaucoma drops
Summary: Key Surgical Steps

1. Visualization
   - excellent microscope (xenon, large tilt)
   - no visco at start
   - hypotony, identify

2. Technique
   - anterior, flared incision
   - no outward push
   - near 180º ablation

3. Reducing hyphema
   - viscoelastic tamponade: after ablation + after phaco
   - pressurize well
Visualization

xenon light, large tilt
What not to do in trabectome surgery
OUTCOMES
Global Outcomes

Phaco-Trabectome

<table>
<thead>
<tr>
<th>Time</th>
<th># Medications</th>
<th># Medications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>2.3±1.2</td>
<td>2.8±1.3</td>
</tr>
<tr>
<td>6M</td>
<td>1.6±1.3</td>
<td>2.3±1.4</td>
</tr>
<tr>
<td>36M</td>
<td>1.9±1.2 (p=0.1)</td>
<td>2.0±1.4 (p&lt;0.01)</td>
</tr>
</tbody>
</table>

Trabectome-only

<table>
<thead>
<tr>
<th>Time</th>
<th># Medications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>2.3±1.2</td>
</tr>
<tr>
<td>6M</td>
<td>1.6±1.3</td>
</tr>
<tr>
<td>36M</td>
<td>1.9±1.2 (p=0.1)</td>
</tr>
</tbody>
</table>
Global Outcomes

Trabectome alone: 64.9%
Trabectome and PCE: 86.9%

Success definition:
No additional glaucoma surgery and
IOP reduction ≥20% from pre-op and IOP <21 mmHg
last 2 follow ups, after 3 months post-op
## Trabectome-Only Results

<table>
<thead>
<tr>
<th>Authors</th>
<th>Study Type</th>
<th># of pts</th>
<th>pre-sx IOP</th>
<th>% decrease</th>
<th>meds decrease</th>
<th>months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minckler, 2005</td>
<td>Pro</td>
<td>37</td>
<td>28</td>
<td>40 %</td>
<td>0.9</td>
<td>13</td>
</tr>
<tr>
<td>Minckler, 2006</td>
<td>Pro</td>
<td>101</td>
<td>28</td>
<td>40 %</td>
<td>n/a</td>
<td>30</td>
</tr>
<tr>
<td>Minckler, 2008</td>
<td>Retro</td>
<td>738</td>
<td>26</td>
<td>35 %</td>
<td>1.1</td>
<td>60</td>
</tr>
<tr>
<td>Ting, 2012</td>
<td>Pro</td>
<td>450</td>
<td>26</td>
<td>34 %</td>
<td>0.6</td>
<td>12</td>
</tr>
<tr>
<td>Ting, 2012</td>
<td>Pro</td>
<td>67</td>
<td>29</td>
<td>44 %</td>
<td>0.9</td>
<td>12</td>
</tr>
<tr>
<td>Jea, 2012</td>
<td>Retro</td>
<td>115</td>
<td>28</td>
<td>41 %</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>Minckler, 2012</td>
<td>Retro</td>
<td>1151</td>
<td>26</td>
<td>36 %</td>
<td>1.7</td>
<td>60</td>
</tr>
<tr>
<td>Mosaed, 2011</td>
<td>Retro</td>
<td>538</td>
<td>26</td>
<td>31 %</td>
<td>0.8</td>
<td>12</td>
</tr>
</tbody>
</table>
## Phaco-Trabectome Results

<table>
<thead>
<tr>
<th>Authors</th>
<th>Study Type</th>
<th># of pts</th>
<th>pre-sx IOP</th>
<th>% decrease</th>
<th>meds decrease</th>
<th>months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minckler 2008</td>
<td>retro</td>
<td>366</td>
<td>20</td>
<td>20 %</td>
<td>1.2</td>
<td>60</td>
</tr>
<tr>
<td>Francis, 2008</td>
<td>Pro</td>
<td>304</td>
<td>20</td>
<td>25 %</td>
<td>1.2</td>
<td>21</td>
</tr>
<tr>
<td>Francis, 2011</td>
<td>Pro</td>
<td>89</td>
<td>22</td>
<td>27 %</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Ting, 2012</td>
<td>Pro</td>
<td>263</td>
<td>20</td>
<td>22 %</td>
<td>0.7</td>
<td>12</td>
</tr>
<tr>
<td>Ting, 2012</td>
<td>Pro</td>
<td>45</td>
<td>22</td>
<td>35 %</td>
<td>0.9</td>
<td>12</td>
</tr>
<tr>
<td>Minckler, 2011</td>
<td>retro</td>
<td>681</td>
<td>20</td>
<td>21 %</td>
<td>0.9</td>
<td>36</td>
</tr>
<tr>
<td>Mosaed, 2011</td>
<td>retro</td>
<td>290</td>
<td>20</td>
<td>18 %</td>
<td>0.8</td>
<td>12</td>
</tr>
<tr>
<td>Kaplowitz, Loewen</td>
<td>retro</td>
<td>192</td>
<td>20</td>
<td>28 %</td>
<td>0.8</td>
<td>24</td>
</tr>
</tbody>
</table>

* including ACG, NVG, uveitic, secondary procedures
6 Year Outcomes

**IOP (mmHg)**

- **n = 3445**

**Glaucoma Medication Use**

- **Mean Number of Medications**
  - **Months After Surgery**
  - **# of Meds Baseline**
  - **# Meds**
  - **Moving Weighted Average (4)**
Trabectome vs. Trabeculectomy  
(Dr. Brian Francis)

Major complications: Trabectome-phaco group including subsequent trabeculectomy & tube = 4

Major complications: Trabeculectomy-phaco group including repeat trabeculectomy & tube = 16

Brian A. Francis; Jonathan Winarko; Clinical & Surgical Ophthalmology 29:2/3, 2011
Trabectome vs. Trabeculectomy (Brian Francis)
Trabectome AFTER Trabeculectomy

Bussel II, Kaplowitz K, Schuman JS, Loewen NA
Outcomes of ab interno trabeculectomy with the trabectome after failed trabeculectomy.
# Medications

<table>
<thead>
<tr>
<th></th>
<th># Medications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>2.5±1.5</td>
</tr>
<tr>
<td>6M</td>
<td>1.8±1.5</td>
</tr>
<tr>
<td>12M</td>
<td>1.6±1.4 (p=0.1)</td>
</tr>
</tbody>
</table>

# Medications

<table>
<thead>
<tr>
<th></th>
<th># Medications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.8±1.2</td>
</tr>
<tr>
<td></td>
<td>2±1.3</td>
</tr>
<tr>
<td></td>
<td>2±1.3 (p&lt;0.01)</td>
</tr>
</tbody>
</table>

Bussel, II et al. BJO (2014)
Trabectome by Degree of Angle Opening

Bussel II, Kaplowitz K, Schuman JS, Loewen NA
Outcomes of ab interno trabeculectomy with the trabectome by degree of angle opening.
Trabectome by Degree of Angle Opening

Total number of cases with 1 year follow-up
n = 682

Exclusion of concurrent surgery other than phacoemulsification
n = 671

AIT
n = 314

Phaco-AIT
n = 357

SG≤2
n = 43

SG≥3
n = 271

SG≤2
n = 48

SG≥3
n = 309
Trabectome by Degree of Angle Opening

![Graphs showing IOP and Meds over time for AIT and phaco-AIT with SG ≤ 2 and SG ≥ 3 categories.](image-url)
Trabectome Matched to Ahmed Valves

N = 15

N = 32 per group

T, A: 3 drops
T: 1.9 drops
A: 4.1 drops
Outcome by Type of Glaucoma
POAG + Pseudoexfoliation

POAG

N=2828

Pseudoexfoliation

N=481
Uveitic + Steroid Glaucoma

Uveitic Survival Plot

N=69

Steroid Induced Survival Plot

N=49
Infantile Glaucoma

Trabectome only

N=18

Phaco-Trabectome

N=10
Highly Complex, Mixed Mechanism Glaucomas

- **Trauma (n=3)**

- **Neovascular (n=3)**

- **Retinal Detachment + Buckle (n=5)**
Trabectome with glued, tied Baerveldt
Wet Lab
WET LAB
Skills Transfer Course

Wet Lab Introduction

Brian Francis MD, MS
Associate Professor of Ophthalmology
Doheny-USC, Los Angeles, California
Trabectome Surgical System

- Handpiece
- Power, IA Line
- Irrigation/Aspiration Unit
- High Frequency Generator
- Clean Tray
- Main Stand
- Foot Control
Unique Key Features
Human Corneal-Scleral Rim Setup

- Human Corneal-Scleral Rim (Inverted Submerged in BSS)
- Trabectome® Handpiece
- Tissue Fixation Needles
- Cup Rotation Adjustment
Human Corneal-Scleral Rim Setup
Handpiece Grip Technique
Trabecular Meshwork Removal

George Baerveldt, MD, University of California, Irvine
CASE PRESENTATIONS
Overview

Case Representations

- Sjogren + Steroids
- Corneal Synechiae, Angle Closure
- Pseudoexfoliation

Historical Cases

- phaco-trabectome in POAG
- phaco-trabectome in PXG
CASE 1:
SJOGREN + STEROID GLC
HPI

- 73-year-old Caucasian woman
- 35 mmHg on 3 gtts
- Severe Sjogren’s Syndrome
  - Severe DES
  - Filamentary keratitis
  - Erosions
  - Xerostomia
HPI

- Prednisone 4 mg QD, KCl 20 mEq QD, Alendronate, Calcium with vitamin D
- Steroid-induced glaucoma OU
  - 50 mmHg max
  - Unnoticed by PMD x 6 months
<table>
<thead>
<tr>
<th>Exam</th>
<th>OD</th>
<th>OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>VA (cc)</td>
<td>20/50</td>
<td>20/200</td>
</tr>
<tr>
<td>Lids</td>
<td>severe crusting</td>
<td></td>
</tr>
<tr>
<td>Cornea</td>
<td>filaments</td>
<td></td>
</tr>
<tr>
<td>Lens</td>
<td>3+ NS, +1 PSC</td>
<td></td>
</tr>
<tr>
<td>Disc</td>
<td>0.9 C/D</td>
<td>0.95 C/D</td>
</tr>
<tr>
<td></td>
<td>Severe inf, moderate sup thinning</td>
<td>Severe inf + sup thinning</td>
</tr>
</tbody>
</table>
Pattern Deviation not shown for severely depressed fields. Refer to Total Deviation.

Fovea: 33 dB  MD: -10.37 dB  P < 0.5%
VFI: 75%  PSD: 9.00 dB  P < 0.5%

Fovea: 29 dB  MD: -24.88 dB  P < 0.5%
VFI: 26%  PSD: 9.55 dB  P < 0.5%
Phaco-Trabectome

OD
- **POD #1**: VA 20/25-2, IOP 10.
- **POM #12**: VA 20/25+, **IOP 12**. No gtts for IOP

OS
- **POV**: 10 mm Hg x 5 months
- **POM #18**: 14 mm Hg (added Travatan Z)
CASE 2:
CORNEAL SYNECHIAE = ACG
HPI

- 81-year-old Caucasian woman
- Deaf mute
- 20 mmHg on 3 gtts + oral CAI
- DSAEK OS years ago
  - 180 corneal-iris touch
  - drops affecting transplant
  - difficult med adherence
<table>
<thead>
<tr>
<th></th>
<th>OD</th>
<th>OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>VA (cc)</td>
<td>20/70</td>
<td>20/150</td>
</tr>
<tr>
<td>cornea</td>
<td></td>
<td>DSAEK</td>
</tr>
<tr>
<td>Iris</td>
<td>180° iridocorneal adhesions</td>
<td></td>
</tr>
<tr>
<td>Lens</td>
<td>0.4 C/D</td>
<td>sulcus PCIOL</td>
</tr>
<tr>
<td>Disc</td>
<td>0.7 C/D</td>
<td>Inf thinning</td>
</tr>
</tbody>
</table>
iridocorneal adhesion

DSAEK
Dissection of Iridocorneal Adhesions
Trabectome Goniosynechiolysis
Trabectome Ablation

open Schlemm's trabectome
Outcome

- POM#18: OS VA 20/60, IOP 12
- timolol QAM
Summary

MIGS vs Trabs/Tubes

Trabectome Technique + Postop Care

Outcomes

Case Presentations
Thank you.
optional:
COST CONTAINMENT IN
GLAUCOMA
COST CONTAINMENT IN GLAUCOMA
The Cause of Glaucoma

Increasing Lifespan

Neanderthal: 20
Upper Paleolithic: 33
Neolithic: 20
Bronze Age: 18
Classical Greece: 25
Classical Rome: 25
Pre-Columbian North America: 30
Medieval Britain: 25
Early 20th Century: 35
Current world average: 66.12
Friedman et al, IOVS, 2007:

- 59% patients had opportunity to fill gtts at 12 months after initial prescription
- only 10% actually had medication available continuously
Costs of Glaucoma Treatment

**Taylor HR, Ophth, 2009**

- $138,000-150,000 USD/QALY
- But: sequence of **SLT, gtts, trab** is very cost effective (instead of max gtts, SLT, trab):
  
  savings would return

  $2.50 for every $1.00 spent

*Performing trabectome early might also keep costs down and improve vision (if done with CEIOL)*