DMEK Insertion & Opening
Water-tight injector & “Bubble Beneath” Methods

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Topics covered:  Donor Selection
                  Prepare the Host
                  Load / Inject the Donor
                  Partial Opening (“A” Opening)
                  Initial Air Bubble
                  Complete Opening
                  Centration
                  Final Air
                  Difficult Cases

Donor Selection
• I recommend donors 60 and over with good cell counts
  o Thicker DM = less curly = opens with less manipulation (therefore less endothelial damage)
  o I theorize selecting older donors with higher cell counts selects for cells that are more resistant to death (they have already passed the trial of time)
  o My preliminary data (unpublished): a series of 42 donors all over 60 years old with high cell counts averaged a 11.5% cell loss at 6 months postop DMEK compared to the eye bank pre-surgical cell counts

Prepare the Host
• Laser PI before the case
  o Avoids bleeding or delayed bleeding from surgical PI (see below, “difficult cases”)
  o Can use light to constrict pupil (not pilocarpine) so that patient can be dilated afterwards for combination Phaco / DMEK
  o Confirm patency of posterior pigment epithelium with bimanual IA during case
• Fixation sutures
  o 4-0 Silk on tapered needle placed about 3-4 mm posterior to limbus superior and inferiorly through conjunctiva and partial thickness sclera (RB-1 needle, K871 suture)

Fixate the sutures to the drapes / nasal canula to keep the eye still and the iris level
• Mark planned donor site
  o Imprint cornea epithelium with same size trephine blade that donor was cut with
  o Make imprint exactly centered or slightly displaced superiorly (so donor will have better air exposure and attach easier)
  o No ink necessary (Drying cornea later allows visualization of imprint)
• Wounds
  o Standard phaco wound (2.4 mm wound)
    ▪ ViscoJet 1.8 mm water tight injector (Bausch & Lomb) used for DMEK fits nicely into this wound
  o Two 1 mm side port wounds 45 degrees to left and right of main wound
• Lidocaine 1% preservative free
• Remove host DM
  o Plan to remove exact size of planned donor or larger
    ▪ Residual tags of DM can impede / delay peripheral donor adherence
  o Reverse Price-Sinksy hook
    ▪ Push to penetrate DM, then lightly drag to propagate score
    ▪ Don’t tear posterior stroma into strands. If hooks gets caught in posterior stromal fibers, disengage before propagating further (posterior stromal strands can impede / delay attachment)
  o If combined with phacoemulsification...
    ▪ Stripping is done while cohesive viscoelastic is in eye (no dispersive viscoelastic!)
    ▪ After scoring, gently lift edge x 360 to verify score is complete
    ▪ Then peel out with DM stripper
    ▪ Remove all viscoelastic (irrigate angle thoroughly)
    ▪ Miochol
  o If DMEK only...
    ▪ Stripping is done with air in AC (better contrast / view) through side ports before 2.4 mm keratome wound is made
    ▪ Air filled canula in non-dominant hand can repeatedly fill AC if it leaks out
    ▪ Reverse Price-Sinksy hook in dominant hand scores and strips DM
    ▪ If iris sticks to cornea (surface tension) added air will only go to posterior chamber… need to add BSS first to break surface tension
• Verify if there are remaining tags
  o Open resected DM on surface of cornea (verify if it appears complete and same size as marked area on surface)
  o Stain for tags (Trypan Blue)
Remove residual tags inside of trephination imprint with **bimanual I&A**

- Verify patency of PI with Bimanual I&A
  - Put aspiration port through PI and gently aspirate any posterior pigment epithelium
- Hydrate wounds (until no leak)

**Load / Inject the Donor**

- Stain the donor

Remove most of storage solution with wek cells (use 2 opposing wek cells so donor doesn’t follow the moving fluid onto the wek cel)

**Drip trypan at one end of the scroll so it percolates into the scroll lumen to stain the DM on the inside of the lumen**

- Staining duration
  - Staying for at least 60 seconds
  - Consider staining for 120 seconds a difficult view is anticipated (corneal edema)
- Prepare the Injector (ViscoJet 1.8 mm, Bausch & Lomb) (Do this during staining)
  - Remove the spring from the injector

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Fill the cartridge with fluid and submerge it
  - To prevent bubble entrapment in the cartridge lumen, start pouring BSS into the cartridge lumen as you move to submerge it in the petri dish filled with BSS

- Load Donor
  - Soak away trypan with 2 wk cells
  - Grasp donor edge with tying forceps and bring it over the petri dish
  - Grasp the cartridge with 0.5 mm toothed-forceps and gently lower the donor in the BSS and let it fall into the open end of the cartridge
  - Gently tap the donor into closed end of cartridge (without touching endothelium)
  - Close the cartridge while it is still submerged and press ends together until they “click”
  - Lift cartridge out of the fluid and load it into the injector while keeping it parallel to the ground the whole time
  - Slowly advance plunger until it engages the cartridge
  - When plunger engages cartridge, tilt open end of cartridge upward and continue to advance plunger slowly
  - If the donor moves towards the distal cartridge opening, gently tap the side of the injector (slight vibrations cause donor to fall proximally again with gravity away from opening)
  - Continue to advance plunger on until it reaches the “watertight” portion of the cartridge
  - Give injector to assistant who will keep it pointing somewhat upward as you position the scope on patient

- Inject the donor
  - Make sure the eye has a physiologic pressure before injecting (the bolus of fluid from the injector will be less likely to cause a high pressure gradient or donor expulsion)
  - Warn patient not to squeeze either eyelid (to minimize pressure) (consider having patients blocked)

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Advanced cartridge into the wound until the distal lumen passes the inner lip of the wound (gently rotating the cartridge 360 degrees while advancing helps)

Before injecting, make sure...

**AC isn’t flat (don’t push donor into a flat AC)**
- Can fill AC through sideport without risk of the pressure causing donor override (because system is water-tight, but don’t overload AC (a risk of donor expulsion during injection)

**Donor is right side up in cartridge (more likely to be right side upon opening)**
- Double scroll (“Dead Sea Scroll” formation) - Easy to tell right side up. Rotate until connecting piece is exactly on the bottom
- Single lumen scroll – Harder to tell right side up. As the right and left edges of the scroll wrap around, their tapered edges make a “V”… rotate until this V is on the top.

- Inject donor
  - If AC shallows or donor bunches up, stop injecting and deepen AC before injecting further

- Disengage donor / Remove cartridge
  - Wiggle cartridge slightly until donor disengages.
  - Allowing anterior chamber to shallow via sideport can secure the donor in the eye before the cartridge is removed
  - Press the main wound shut while removing cartridge
  - If the donor expulses some through the wound, either pull it into the eye with a Tan forcep or pull out of the eye and reload it (such expulsions can be surprisingly well-tolerated with minimal endothelial cell loss)

- If the donor tip is still in the wound
  - Press on the wound with a canula to “milk” it into the AC (need AC *slightly* filled for this)

- Suture the wound (minimizes extrusion risk)
  - Technique to minimize fluid leak during suture needle pass
    - Pass needle first through sclera while gently lifting anteriorly, then rotate to exit through cornea with counter pressure on corneal surface. This minimizes wound gape.

**Partial Opening (Mechanical “A” Opening or External taps)**

*Use CANULA GOING THROUGH A WOUND for fluid in this step, because it allows the AC to be deepened and shallowed at will*

- Always pass some fluid through canula before entering the eye so that stray bubbles (which could impede donor movement) are not randomly released
- Don’t over-pressurize donor AC to prevent donor extrusion

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• Rotate donor scroll as necessary until its lumen is at one of the wounds (AC needs to be slight depth
  o Circumferential BSS currents sent around the angle can rotate donor (Geibel) (don’t overpressurize… can extrude)
  o Strokes on external surface of cornea can create these currents too
• Try to ensure that the donor is roughly centered now
  o Gently milk the donor to the center of the eye by pressing on corneal epithelium with canula (a quick “Golf Swing” on the corneal epithelium can help to center a stubborn donor)
  o (Once the initial air bubble is placed later, donors often do not completely open well or do not center well if they decentered into the AC angle… the rare donor is so “sticky” that it hardly centers at all, so it is helpful to have the donor somewhat centered to start.)
• Partially open donor (Mechanical “A” opening)
  o Use long (10 mm) 30 gague canula on 10 mL syringe
  o Burst BSS into lumen of donor
  o Push with cannula and BSS on left and right on inner walls of scroll (DM side of donor… always curls with endothelium outside)... donor forms the capital letter “A”
  o Once partially open, let chamber shallow some to hold the donor in the partially open form (donor is “kissed” between iris and cornea)
    ▪ It is often not possible to shallow the chamber at all in eyes status post vitrectomy (thus the donor re-scrolls immediately). (See section below)
  o Mechanical “A” opening works on both single and double lumen scrolls
  o External taps in the center of the donor works to open a right side up double lumen scroll. (See Dr. Straiko’s handout for more details on this technique. Dr. Straiko also discusses another technique to open a single lumen scroll.)
• Check orientation
  o Because endothelium is on the outside of the scroll…
    ▪ A donor that is right side up will make a “U” on cross-sectional view with the upper edges of the “U” curling back down on the middle of the U.
    ▪ A donor that is wrong side up will make an “n” in cross-sectional view
  o While donor is held open, confirm orientation with…
- Canula test (Moutsouris Sign) - Lower canula onto connecting piece between left and right curl then slide to the side. If the canula tip changes blue at the curl, donor is in correct configuration. (Requires excellent view through cornea and darker stain.)

- Eidolon hand held slit beam – Slit beam view of donor verifies confirmation (turn off scope light and use slit beam)

- This slit beam is particularly bright because it condenses light into a focal line with a cylindrical lens (visible on hazy corneas)

- Flip as needed
  - Send a current under or over the donor to flip it (Geibel)
- 50/50 fold (another use for “flip current”)  
  - If the donor partially opens only to be folded in half, it will be difficult to push left and right to form an “A” opening (pushing or blousing BSS towards the side of the crease will only move the donor into the angle and risk endothelial damage) and external taps wound help
  - Instead, you need to send a “flip current” under the donor from the crease side... but don’t flip it all the way: stop when the donor has returned to “dead sea scrolls” conformation.
    - Then try “A” opening or external taps again, shallow the AC, and verify orientation
Initial Air Bubble

*Use 30 GAUGE NEEDLE ON A 1 ML SYRINGE for this step (not a canula going through the wound), because it keeps a closed system so that fluid currents do not move the donor out of position*

- Start with 0.05 mL of air in syringe
- Enter corneal limbus parallel to iris
- Carefully move toward center of pupil between donor and iris (if iris is snagged, slowly back up and redirect)
- Inject air and withdraw needle (ideal air bubble is about 2 mm wide… sometimes a bigger bubble helps open the donor more, but a smaller bubble is useful when centering the donor)
- Donor should rise to the corneal stroma
- It is now safe to carefully deepen the AC with BSS through the wound and the donor will not scroll back up

Complete Opening

*(Assistant keeps cornea moist to prevent defect when touching epithelium)*

- Usually, the portions of the donor to the left and right of the central bubble are still folded over
- Golf swings can center DMEK donors far easier than DSAEK donors… but DMEK donors typically don’t center well until they are completely open
  - Golf swings placed before donor is fully open often cause peripheral folds to enlarge (making it LESS opened)
- Special techniques help open these remaining folds
  - Bubble bump (Droutsas Taps) – Push on bubble to displace it into the peripheral folds to knock them open (bubble bump won’t work for “point-locked folds”)
  - “Point-Locked Fold” Release (Tenkman Touch) – If upon elevating the donor to the corneal stroma, the air bubble bends one of the peripheral folds, a crease is made in the middle of the fold (which can be seen as a angulated point on the edge of the fold).
This locks the fold and it will not open with simple bubble displacement. The solution is to take the straight edge of the canula, hold it parallel to the edge with the fold, press just peripheral to this fold, wait for the crease to release (the point goes away and the edge becomes straight again), and then let go. **“Push and hold to unlock a fold.”**

- If the fold is “sticky”, it may require several tries to unlock it or to get it opened all the way.
- To unlock a stubborn fold: while pressing, rub up and down on the edge of the donor and side to side across the fold to encourage the crease to release.)

- VERY large folds may be too difficult to release. If so, remove the air bubble and try to create a LARGER “A” opening before adding the initial air bubble.

- Center & Open in one motion (Price Pull) – If a donor is decentered too much towards the angle, there may be no room to open the donor all the way on the side towards the angle. Tilt the eye so that the donor will be “moving downhill”. Perform a “Golf swing” with a vector striking just central to the fold and moving towards the center of the donor. The donor will move downhill towards the center of the centration imprint and will start to unfold in one motion.
  - Starting vector peripheral to the fold will instead ENLARGE the fold
  - Will not work for “point-locked folds”. Need to unlock the fold (Tenkman Touch) before performing the Price Pull.

**Centration**  
(Assistant keeps cornea moist to prevent defect when touching epithelium)
- Tilt eye in the direction you want the donor to move (Geibel)
  - This puts gravity on your side
  - Release and hold the fixation sutures to tilt the eye
- “Golf Swing” (Geibel)
o Stroke across the corneal epithelium over the donor in the vector you want it to move (and it will!... if it is fully open)

• Dry the cornea to check centration
  o Be sure to align the donor as perfectly on the epithelial trephine imprint as possible

• Re-wet cornea and re-center as needed

Final Air
Use 30 GAUGE NEEDLE ON A 1 ML SYRINGE for this step (not a canula going through the wound), because it keeps a closed system so that fluid currents do not move the donor out of position

• Clamp fixation sutures again
• Enter corneal limbus with 1 mL syringe mostly full of air
  o Air can consist of regular room air or a non-expansive longer lasting gas such as 5-10% SF6 or 5-10%C3F8.
  o Air reinjection rates with room air are often 20% in the postop period.
  o Air reinjection rates with long acting gases are usually < 1%, but they reduce the endothelial cell count by 20-40% (depending on concentration)

• Place needle bevel just below initial air bubble
• Inject air in an attempt to join it to the initial air bubble (prevent cavitation damage from multiple bubbles joining)
• Expand air bubble until it is about 1-2 mm from the limbus, with a physiologic IOP, and the air bubble NOT being so big that you can see it touching the IOL below. (Phakic DMEK is harder to gague the right air amount)
• Compress needle tract shut with tying forceps when exiting needle (to seal the tract and prevent air escape)
• Avoid hypotony
  o This aids attachment significantly
  o You don’t want the eye to be so soft that a strong blink can indent the cornea and allow fluid into the interface (consider avoiding IOP medications as part of your postop routine unless pressure becomes unacceptably high)

• Signs that there is too much air / pressure
  o Patient loses light perception (check by covering and uncovering their eye and verifying they see the scope light going “on and off”)
  o When scope light is blocked from their eye, patient still sees “sparkles”
    ▪ This is a sign of watershed zone ischemia in the peripheral retina
  o Pupil seems to be pushed far posterior into lens
    ▪ Even if air bubble is 1mm away from limbus, if the posterior chamber is collapsed at this time, the air will comprise a higher volume of the AC as the air pushes the fluid from the AC through the PI into the collapsed posterior chamber. As the
posterior chamber expands, the relative AC volume the air comprises increases (then the air may cover the PI)

**Difficult Cases**

**Bleeding**
- **Sources**
  - Surgical PI
  - Suture passing through sclera to close wound
- **Problem**
  - Clot can entangle a donor in a sticky gelly-like mess that is difficult or impossible to disentangle
- **Solution**
  - Do LASER PI instead of surgical as mentioned above
  - Try to not put donor in until bleeding is stopped
  - If bleeding starts AFTER donor is in, you have to deal with it:
    - **Stop the bleeding:** Cautiously elevate IOP with BSS until light is somewhat dim (not to NLP) then release IOP after 90-120 seconds
      - Needs to be done VERY carefully if the donor is already in the eye to prevent extrusion
    - Remove the clots (clots can prevent a donor from opening or centering properly)
      - Can be removed with bimanual I&A or forcep if donor is not in the eye (these are too high risk of damage / extrusion of donor if donor is still in the eye)
      - Need remove with a closed system approach if donor is already in the eye (See Tenkman’s “Blood, Sweat, & Cheers” from ASCRS 2013 Film Festival)
        - To remove clots from donor lumen: use 30 gauge needle to “aspirate and occlude” on clot (as with phacoemulsification) then pull it out of the lumen
        - To remove clots from outside the donor lumen, use this 30 gague needle to sweep clots away

**Status post Vitrectomy**
- **Problem** – the scroll won’t stay open with “A” opening because the AC often won’t shallow, so the initial air bubble cannot be placed
  - Some post vitrectomy eyes can be shallowed for a brief period (and you just have to act fast)
  - Sometimes you are lucky and these eyes behave as if have not had vitrectomy
  - Many won’t shallow **AT ALL**
- **Solutions**
  - Go for a “Tri-Fold” (“Pilgrim Hat” per Dr. Ing)
A “triple lumen” scroll (as apposed to “dead sea” double lumen scroll) holds itself open (doesn’t rely on a shalllowed AC to hold it open)
Without a shallowed AC to hold it open, these tri-folds often convert to a double lumen scroll after a few seconds. The shortest edge of the trifold often comes undone due to the elastic tension of the larger scrolls.
Act quickly:
• Leave the eye slightly soft during these cases
• Quickly get air on the 30 gague needle and indent the cornea immediately adjacent to the “short edge” of the trifold. If you indent enough, contact between the cornea and the short side of the donor the prevents the larger folds from forcing the small fold out (thus keeping it open as a trifold hopefully long enough to get the initial air bubble in)
  o Have a reliable assistant stationed at the microscope...
    ▪ Hold an instrument in pars plana to elevate IOL forward to shallow the chamber on your command.
    ▪ …and cautiously proceed as above
    ▪ OR… Inject air while you hold the donor open with 2 forceps
  o Do thin DSAEK instead
    ▪ Don’t have to worry about shallowing chamber to open

Sticky donors
• Some donors are just “sticky” such that they do not center well with golf swings once all the way unfolded
  o In my experience (unpublished), if one donor is “sticky”, then its mate will be sticky in the next patient
  o Also, in my experience, it is sometimes the host that is “sticky”, meaning that the donor their second eye will be difficult to center
• Solutions
  o Make the air bubble smaller and try to center again
  o Remove the air bubble, center the donor by milking it to the center, then reopen and try again
  o Press the donor edge with a canula and drag it (often works)
  o Use a tan forcep to move it (last resort)
    ▪ This risks having the donor extrude as the donor could follow the current of fluid that leaves the wound around the Tan forcep
    ▪ I’ve had one donor pair that wouldn’t center and was difficult to separate from the host cornea even after removing all air… I centered these with a slight grab from a tan forcep

Curly donors (younger donors)
• Problem

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These donors are hard to open because of their curl

- **Solutions**
  - “Big bubble opens, small bubble moves” (Giebel)
    - You may have to gradually expand the initial air bubble as you are able to open the donor more (to hold each success)
    - A big bubble creates too much friction to allow reliable centration (the bubble may have to be reduced prior to centration)
  - Open donor with shallow AC and no air
    - External taps / spreading of two cannulas (Dr. Ing will discuss this)
  - *Just avoid donors under age 60!*