A Treasure Chest of Technological Innovations in Eye Care
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1. Lasers
   a. Femtosecond lasers
      i. Femtosecond lasers work on extremely small wavelength – 10 to the -15 orders
      ii. They can cut through tissue with little energy dispersion
      iii. Applications include:
         1. LASIK
         2. Penetrating keratoplasty
         3. Lamellar keratoplasty procedures (where only sections of the cornea are removed)
            a. DSEK – or endothelial keratoplasty
            b. DALK – deep anterior lamellar procedures
            c. Shallow lamellar procedures for a stromal scar closer to the surface
   4. Cataract surgery – this is a big breakthrough currently
      a. Three companies developing the technology
      b. LensX, LensAR and Opticomedica
      c. Femtosecond lasers can be programmed to create a perfect capsulotomy
      d. Femtosecond lasers can then be applied to liquify the lens so all that is necessary is aspiration
      e. Now being tested by LensAR for treatment of the lens to soften it and possibly restore accommodation
      f. Can possibly be used to remove the yellowing of a cataract lens and perhaps restore clarity
   5. Intra-lamellar refractive surgery
      a. Femtecc is working on correcting small levels of refractive error and presbyopia patterns without a flap or epithelial removal
      b. Can correct up to 1.5 Diopters of myopia or restore 1.5D of accommodation via an intrastromal ablation

2. Mechanical MGD treatment
   a. TearScience technology for 20 minutes of head and massage to meibomian glands
   b. Similar to dialysis – patients come in for 20 minutes and have the MG’s ‘cleaned’
   c. Patients are typically fine for 6-12 months without symptoms in 79% of cases
3. Dry Eye Imaging
   a. LipiView
   b. Keratograph M5
      i. Tear film break up non invasive
      ii. Meibomography, lipid layer assessment etc.
   c. Cassini topography with LED
   d. Annidis RHA – meibomian gland assessment and vascular flow

4. UV light - Corneal cross-linking (CXL)
   a. Apply riboflavin drops until well absorbed in the cornea
   b. Riboflavin prevents absorption and prevents cataracts or macular damage
   c. Requires application every 30 seconds for 30 minutes while UV light is applied
   d. Allows the corneal fibers to enhance cross linking
   e. Prevents any further progression of keratoconus
   f. On average patients improve by 3.5 Diopters on keratometry
   g. Can apply PRK afterwards or a contact lens that could reshape the cornea
   h. Being investigated for the treatment of bacteria and could be used for conjunctivitis or microbial keratitis

5. Light adjustable IOL
   a. New IOL following cataract surgery currently available in Europe
   b. 6 mm silicone optic and PMMA haptic IOL
   c. Using a Yag laser the IOL is designed such that laser treatment can change the refractive error if there are refractive surprises
   d. Especially beneficial in patients who have difficult biometry such as those with previous refractive surgery or keratoplasty procedures

6. Drug delivery systems
   a. Premise is that longer drug contact times or constant exposure is better than periodic dosing
   b. Zero order kinetics – means the same amount of drug is eluded every day
   c. Could eventually replace injections or even eye drops
   d. Contact lens eluding
      i. Ketotifen will likely be first to release allergy meds via the contact lens over 1-2 weeks
      ii. Patients who suffer from allergies and want to wear CL are ideal candidates
      iii. The future involves glaucoma medications being studied
      iv. Bacterial resistance materials within a contact lens
v. Also a contact lens that will release mitomycin C to be placed as a bandage lens after surgeries such as PRK or a trabeculoplasty
vi. Prototype lens releasing ciprofloxacin was shown to inhibit staphylococcus aureus for over a month (Ciolino, Kohane et al)
vii. Vitamin-fortified contact lens
   1. Contains Vitamin E which helps deliver more medication for glaucoma to the eye
   2. Allows 100 times longer glaucoma medications contact than currently possible
viii. Stem cell coated contact lenses for patients with their own stem cell corneal disease
   1. Will help patients with chemical burns, aniridia, pemphigoid etc.

e. Punctal plugs
   i. In phase II trials to release latanoprost over 3 months in a punctal plug
   ii. New study using steroid and antibiotic post cataract surgery
   iii. No drops required

f. Transscleral drug-delivery patches
   i. A series of micro-needles that are imbedded in a micro patch that can be placed on the upper conjunctiva
   ii. Could replace the need for injections
   iii. Has medications on the patch and then micro-needles that deliver it into the eye

7. Nanotechnology
   a. MEMS
      i. Definition
         1. Micro-electromechanical systems
         2. Combine circuitry with tiny, nano-scale gears on a sliver of silicone
      ii. Applications
         1. Contact lenses equipped with MEMS to monitor IOP throughout the day
         2. Can have a sensor attached to send a signal to have a patient add an IOP lowering drop
         3. Called Triggerfish
         4. May also work in patients with a strong family history of glaucoma to monitor for IOP spikes as a diagnostic test
b. Liquid bandage
   i. OcuSeal liquid bandage for wound sealing
   ii. Also provides a protective barrier against microbial agents after surgery
   iii. May eliminate the need for sutures involved in various surgeries
   iv. Once spread on the wound the material which is 85% water interacts with the underlying tissue to form a seal that lasts for 2-3 days

c. Nano antibiotics
   i. Starpharma has developed a chemically engineered polymer called VivaGel that works as a microbicide that works by inhibiting herpes simplex virus


d. Nano scaffolding
   i. An infection of nerve scaffolding at the nano level that can allow neural regeneration
   ii. Inject into the diseased optic nerve (end stage glaucoma, AION or traumatic nerve damage) and the nerves will grow in the scaffolding and regenerate
   iii. Early trial showed full regeneration of a severed optic nerve in a mouse model

8. Point of Care Diagnostics

   a. AdenoPlus Detector
      i. Adenodetector
      ii. 3-5 minutes
      iii. Conjunctival swab
      iv. reading the applicator as positive, negative or not properly performed

   b. TearLab
      i. Osmolarity testing
      ii. 3-5 seconds
      iii. Osmolarity has the highest predictive value of any dry eye test
      iv. Normal < 300mOsmol/L and tight Delta between eyes (<6 mOsmol difference)
      v. Dry eye > 300-320 mOsmol/L mild, 320-340 moderate and > 340 severe with Delta > 6 typically
      vi. Monitoring patient results

   c. InflammaDry
      a. Measures MMP-9 levels
      b. Over 40 is a positive measurement
      c. 10 minute test

   d. Other applications to point of care
      i. IgE
      ii. Diabetes
ii. Systemic diseases?

Cognoptix

v. Point of care for Alzheimer's diagnosis

vi. Fluorescent Ligand Scanning (FLS)

vii. Beta amyloid-specific small molecules is dropped into a patient’s eye, which is scanned by the Cognoptix SAPHIRE instrument

viii. The small molecules are absorbed into the lens and bind to the amyloid aggregates

ix. The FLS system excites the fluorescent ligands that bind to amyloid

   d. ClearPath DS
   i. Autofluorescence of the crystalline lens
   j. Higher readings indicate poor glucose control
   k. AGE’s binding
   l. Early detection of DM – as much as 6 years earlier than ocular signs

9. PSF Phoropters and other measurement advances
   a. Developed by Shui Lai PhD
   b. Invented the femtosecond laser, Ophthonix etc.
   c. Uses point-spread-function
   d. Measures accuracy to 0.05D or less but human capability is typically 0.05D
   e. 1-3 minute refraction
   f. Lenses matching findings designed via free-form technology
   g. Optalign
      a. Asthenopia symptoms similar to dry eye
      b. Often vertical imbalance, convergence insufficiency or esophoria
      c. Prism correction

10. 3-Dimensional Testing
    a. TruVision Systems
    b. Flat screen panel display
    c. Excellent depth of field for microsurgery
    d. Better ergonomics
    e. Overlay Technology
    f. OCT testing - anterior seg
       a. Visante and other OCT systems
       b. Value of imaging
       c. Angles
       d. Scleral lens assessment

11. Lamellar surgery
    a. Artificial corneas
a. Alphacore and Boston K-Pro
b. Survival results
b. DALK applications and definition
c. DMEK and DSEK applications and definition
d. Intrastromal lamellar procedures

12. Gene Therapy
   a. Genetic variants causing disease are being discovered
   b. Includes Fuchs, glaucoma, ARMD, corneal dystrophies etc.
   c. Once the abnormality is discovered then attempts to repair it via medications will be attempted
   d. Many ocular disease applications being looked at now especially rare conditions such as RP
   e. Ocular anatomy and architecture are uniquely situated for gene-based research
   f. MaculaRisk assessment with cheek swap technology as an example

13. Limbal Stem Cell research
   a. Current understanding of limbal stem cells
   b. Corneal stem cells
   c. Stem cell deficiency
   d. Limbal stem cell transplantation
   e. RPE stem cell transplantation
   f. Stem cell coated contact lenses

14. Advances in Contact Lens Technology
   a. IOP measuring with Sensimed technology
   b. Photochromic
   c. Coated lenses to prevent contamination, allergy etc.
   d. Myopia control contact lenses
   e. Glucose sensing contact lenses

15. Amniotic Membrane technology
   a. ProKera amniotic membrane
   b. Harvesting
   c. Utilization and clinical cases that apply
   d. Passive vs. Active healing
   e. Ocular Surface disorders that may benefit
   f. The procedure including insertion, tapesorrhaphy and removal

16. Presbyopia correction
   a. KAMRA inlay
      a. Pinhole depth of focus
      b. Design and engineering
      c. Funduscopic examination
      d. Cosmesis
e. Results
b. Presbyopia correction IOLs
   a. Dual optic
c. Presbyopia drops!

17. Advances in neurological testing – RAPDx and New Color Vision testing
   a. Pupil testing accuracy
   b. RAPD measurement and what it means
   c. Applications to glaucoma
d. Color vision assessment advances

18. Miscellaneous technologies
   a. Google Glass
   b. Visually Evoked Potential (VEP)
c. Anti-VEGF applied topically