INNOVATIONS IN TECHNOLOGY LECTURE

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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 programed 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. Femtec 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

    b. Mechanical MGD treatment
        i. TearScience technology for 20 minutes of head and massage to meibomian glands
        ii. Similar to dialysis – patients come in for 20 minutes and have the MG's 'cleaned'

iii. Patients are typically fine for 6-12 months without symptoms

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

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

2. 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 cirprofloxacin 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. Having difficulty with retention rates

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

3. 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
        iii. Pixel Optics electroactive lenses
            1. Involves a layer of liquid crystal between two spectacle lens materials
            2. Electronics housed in the temple so that when a patient looks down the lens changes power
            3. Could replace bifocals for use
            4. Will be a great enhancement for a PAL
            5. Instant change in 0.26 seconds

6. Can be set for distance or near simply by swiping the temple

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

5. Point of Care Diagnostics

a. Rapid Pathogen Screening
    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 < 308 mOsmol/L
    v. Dry eye > 316 mOsmol/L
    vi. Monitoring patient results

6. Specular Microscopy
    a. 240 times the magnification
    b. Polymegathism
    c. Pleomophism and other early signs of endothelial stress
    d. when to image

7. VMax Phoropters
    a. Developed by Shui Lai PhD
    b. Invented the femtosecond laser, Ophthonix etc.
    c. Uses point-spread-function
    d. Measures accuracy to 0.05D
    e. 1-3 minute refraction for staff
    f. Lenses matching findings

9. 3-Dimensional Testing
    a. TruVision Systems
    b. Flat screen panel display
    c. Excellent depth of field for microsurgery
    d. Better ergonomics
    e. Overlay Technology

10. 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