Course Title

Contact Lens Tech and AI Uses

Contact Lens Innovation Symposium

Vision Expo West 2025

Course Length - 1 Hour

Course Instructors - Moderator: Melissa Barnett, Panelists: Avani Dave, Pavan Avinashi

Course Description -

This course explores how advanced technologies and AI are revolutionizing contact lenses to improve fitting precision, accelerate patient satisfaction, enhance ocular disease management, and enable smart lenses with biosensing, drug delivery, and remote monitoring capabilities.

Learning Objectives -

1. Identify current and emerging technologies that enhance contact lens fitting, design, and patient outcomes.

2. Describe the clinical applications and potential of smart contact lenses in diagnostics, drug delivery, and remote monitoring.

3. Evaluate the role of artificial intelligence in contact lens innovation, including patient care, compliance, and personalized treatment planning.

Course Outline

Technology for Specialty Contact Lenses

- Incorporating advanced technology streamlines the fitting process, improving clinical outcomes and efficiency
    - Reduction in chair time
    - Reduce the number of remakes/readjustments
    - Achieving patient satisfaction faster
    - Opportunity for growth and referrals by differentiating from other practices
    - Ability to charge higher fees
    - Limit long-term ocular complications due to more precision

- Types of Technology:
    - Image-guided technology creating empirical designs
        - Orthokeratology, Rigid Gas Permeable and Scleral Lenses
        - Partnerships between industry (Imaging with Manufacturers)
    - Impression-guided technology

Smart Contact Lenses

- Applications in early detection/diagnoses, monitoring, and treatment of ocular diseases (dry eye, glaucoma, diabetic retinopathy)
    - Embedding miniature electronic devices
        - Record biomarkers and physical ocular properties
        - Controlled drug delivery and moisture release
        - Remote monitoring (IOP, glaucoma, inflammatory markers)
    - Transmission of information to external devices (i.e. smart phones or medical monitoring devices)

- Biocompatibility Challenges: Complex manufacturing, scaling issues, and patient comfort. Most studies have a small sample size and short usage periods (<72 hours)
- Safety Challenges: patient compliance with contact lens hygiene
- Research limitations: At an early stage with in vitro or anisomal models
    - Challenges with sensor integration without obstructing vision, environmental sensitivity to temperature, and humidity
- Commercial Barriers: FDA approval, manufacturing scalability, cost vs. insurance coverage limiting patient access
- Privacy Barriers: Encryption of data transmission and storage given patient health information

Biomaterials for Smart Contact Lenses:

- Combines conductive materials (graphene, silver nanowires, gallium-indium alloys) with hydrogel materials (Silicone, PMMA, PHEMA, PDMS)
    - Graphene (popular choice): strength, conductive, transparent, flexible, biocompatible
    - Coatings can shield the ocular surface from electromagnetic waves, preventing dehydration

IOP Monitoring:

3 Methods:

1. *Capacitive Sensors*

- Dielectric layer between electrodes conforms to corneal curvature and IOP induced compression increases capacitance
- Key designs include wireless hydrogel-based SCL for real time IOP monitoring (Zhu et al 2022) and cantilever circuit system that combines IOP with ocular drug delivery (Yang et al 2022)

2. *Strain Sensors*

- Detect mechanical changes of lens material and convert to electrical signals which produces high sensitivity, flexibility, transparency and biocompatibility
- Example: Sensimed Triggerfish (FDA Approved SCL for 24 hour IOP monitoring, clinical safe however data difficult to interpret)

3. *Microfluidic Channel Sensors*

- IOP changes deform cornea, displacing fluid in microchannels and the movement of fluid correlates with pressure levels
- Designs can be integrated with visual and smartphone tracking as well as drug delivery i.e. IOP triggered or blinking induces drug flow through channels
- Pros: No power source, Cons; risk of leaks, clogs and irritation (Prototypes by Yuan et al and Agaoglu et al)

Glucose Monitoring:

Park et al. (2024) developed a smart contact lens glucose biosensor with embedded electrodes coated with glucose oxidase, using Prussian blue for electron transfer, and wirelessly transmitting data

Lactic Acid:

Thomas et al. (2012) explored lactate sensors using lactate oxidase in SCLs, which may be useful for athletes or ischemic conditions

Drug Delivery:

Dry Eye Therapy

- Innovation: Sun et al (2024) developed a contact lens that releases levofloxacin and diclofenac in response to elevated ROS (Reactive Oxygen Species) at areas of ocular inflammation
- Potential: Administer therapy and monitor disease progression by creating a personalized system to adjust drug release based on levels
- Benefits: consistent therapeutic drug levels, reduces antibiotic resistance risk, improves patient compliance in dry eye and post-op care

Glaucoma Therapy

- Innovation: Kumara et al (2024) developed a contact lens that delivers latanoprost or a dual latanoprost + timolol system triggered by lysozyme in tears

Contact Lenses and Artificial Intelligence

- The growing role of AI in healthcare and optometry

AI in Contact Lens Development

- Material Innovation

- AI-driven simulations for new lens materials and coatings

- Enhanced oxygen permeability, comfort, and biocompatibility

Design Optimization

- AI-powered modeling for individualized lens geometry
- Predictive algorithms for stability and centration

AI in Contact Lens Fitting

- Topography and Tomography Integration
- AI-assisted interpretation of corneal data (e.g., for scleral or ortho-k lenses)

Automated Fitting Tools

- Virtual try-on and smart fitting software
- Reduction in chair time and diagnostic fitting sets

Smart Contact Lenses

Biosensing Capabilities

- Glucose monitoring, intraocular pressure, tear film biomarkers

- AI for real-time data interpretation and alerts

Drug Delivery & Telehealth Integration

- Controlled drug release + remote monitoring via AI platforms

AI in Patient Monitoring & Compliance

- Wearable Tech Integration
- Apps and sensors for tracking wear time, hygiene, and symptoms

AI Chatbots & Virtual Assistants

- Supporting patient education and adherence to care plans

Challenges and Ethical Considerations

- Data Privacy and Security

- Regulatory Hurdles

- Training for Eye Care Professionals

The Future of AI and Contact Lenses

- Predictive analytics for disease progression (e.g., keratoconus)
- AI-driven personalized care plans
- Interdisciplinary collaboration: optometry, engineering, and data science
- AI is not replacing practitioners, but empowering them