



**University of Al-Mustaqbal**  
**College of Science**  
**Department of Medical Physics**



AL- Mustaqpal University

Science College

Dep. Medical physics

***Medical Laser Applications***

Third Stage

Lec 3

***Laser eye surgery***

***Asst. lec. Ali Salman Hamadi***

***Asst. lec. Duaa Saad Shakir***

## **1. Introduction**

### **A. What is Laser Eye Surgery?**

- Definition: A medical procedure that uses lasers to reshape the cornea to improve vision.
- Applications: Treats refractive errors such as myopia (nearsightedness), hyperopia (farsightedness), and astigmatism.
- Common techniques: LASIK (Laser-Assisted In Situ Keratomileusis), PRK (Photorefractive Keratectomy), and SMILE (Small Incision Lenticule Extraction).

### **B. Relevance to Physics**

- Role of laser-tissue interactions.
- Precision optics and wavefront-guided treatments.
- Application of principles like energy transfer, wave propagation, and material ablation.

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## **2. Basics of Vision and Refractive Errors**

### **A. The Human Eye as an Optical System**

- Cornea and lens: Focusing light onto the retina.
- Refractive index differences in the eye's components.

### **B. Refractive Errors**

- Myopia: Light focuses before the retina.
- Hyperopia: Light focuses behind the retina.
- Astigmatism: Uneven focusing due to an irregular corneal shape.

### **C. Goal of Laser Surgery**

- Reshape the cornea to correct light focusing.

### 3. Physics of Lasers

#### A. Laser Fundamentals

- **Definition:** Light Amplification by Stimulated Emission of Radiation.
- Coherence, monochromaticity, and collimation properties.
- Energy concentration for precise tissue interactions.

#### B. Types of Lasers Used

- **Excimer Laser:** Ultraviolet (UV) light (193 nm) for ablation.
    - Precise removal of corneal tissue with minimal heat transfer.
  - **Femtosecond Laser:** Infrared light for creating corneal flaps.
    - Produces short pulses with extremely high intensity.
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### 4. Laser-Tissue Interaction

#### A. Mechanisms of Action

- **Photochemical Ablation:** UV photons break molecular bonds in the corneal tissue.
- No thermal damage due to short pulse duration and low penetration depth.
- Accuracy: Ablation depth of approximately 0.25 micrometers per pulse.

#### B. Precision and Control

- Wavefront analysis to guide treatment.
- Importance of beam shaping and spot size control.

#### C. Thermal Effects and Safety

- Avoidance of collateral damage.
  - Cooling systems to maintain corneal integrity.
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## 5. Laser Eye Surgery Techniques

### A. LASIK

- Steps: Corneal flap creation (femtosecond laser) → Excimer laser reshaping → Flap repositioning.
- Recovery: Rapid visual improvement with minimal discomfort.

### B. PRK

- Steps: Removal of the corneal epithelium → Excimer laser reshaping.
- Recovery: Longer healing time but avoids flap complications.

**PRK** stands for **Photo Refractive Keratectomy**.

It is a type of refractive eye surgery used to correct vision problems like :

- **Myopia (nearsightedness)**
- **Hyperopia (farsightedness)**
- **Astigmatism**

**PRK** reshapes the cornea using an excimer laser, allowing light entering the eye to focus correctly on the retina for improved vision.

Unlike **LASIK**, **PRK** does not involve creating a corneal flap, making it a good option for patients with thinner corneas or those at higher risk for flap complications.

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## 6. Physics Challenges and Advancements

### A. Wavefront-Guided Surgery

- Measures and corrects higher-order aberrations for sharper vision.
- Relies on precise optical imaging techniques.

### B. Future Developments

- Adaptive optics and real-time imaging.
- Integration of AI for improved surgical planning and outcomes.

## **7. Risks and Limitations**

### **A. Common Side Effects**

- Dry eyes, glare, and halos.

### **B. Limitations**

- Not suitable for individuals with certain eye conditions (e.g., thin corneas).

### **C. Role of Physics**

- Advances in laser technology and imaging to minimize risks.
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## **8. Summary**

A. Laser eye surgery is a remarkable application of physics in medicine.

B. Involves advanced understanding of optics, laser-matter interactions, and wavefront technology.

C. Ongoing developments continue to enhance precision and safety.

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## **9. Discussion and Questions**

- How does laser wavelength affect tissue interaction?
  - What are the key challenges in wavefront-guided laser correction?
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## **Discussion**

**1. What is the primary purpose of laser eye surgery?**

- A. To replace the cornea
- B. To reshape the cornea and correct refractive errors
- C. To treat cataracts
- D. To enhance color perception
- E. To diagnose eye diseases

**Correct Answer: B**

**2. Which of the following is not a refractive error treated by laser eyesurgery?**

- A. Myopia
- B. Hyperopia
- C. Glaucoma
- D. Astigmatism
- E. None of the above

**Correct Answer: C**

**3. What does LASIK stand for?**

- A. Laser-Assisted In Situ Keratomileusis
- B. Laser-Assisted Corneal Reshaping
- C. Light Amplification Surgery for Keratoplasty
- D. Laser-Assisted Interstitial Keratoplasty
- E. Light Amplification by Stimulated Keratomileusis

**Correct Answer: A**

**4. Which property of lasers ensures precise tissue interaction?**

- A. Coherence
- B. Randomness
- C. Thermal diffusion
- D. Broad wavelength spectrum
- E. Low energy density

**Correct Answer: A**

5. **What is the wavelength of the excimer laser used in laser eye surgery?**

- A. 532 nm
- B. 355 nm
- C. 193 nm
- D. 1064 nm
- E. 800 nm

**Correct Answer: C**

6. **What does PRK involve that makes it different from LASIK?**

- A. Creation of a corneal flap
- B. Removal of the corneal epithelium
- C. Use of femtosecond lasers
- D. Shorter recovery time
- E. Reshaping the lens

**Correct Answer: B**

7. **What mechanism does the excimer laser use to reshape the cornea?**

- A. Thermal ablation
- B. Photochemical ablation
- C. Ionization
- D. Radiation therapy
- E. Electromagnetic induction

**Correct Answer: B**

8. **Why is PRK preferred for patients with thin corneas?**

- A. It uses femtosecond lasers exclusively
- B. It avoids the need for creating a corneal flap
- C. It has a shorter recovery period
- D. It does not require anesthesia
- E. It requires fewer lasers

**Correct Answer: B**

9. Which component of the eye is primarily reshaped during laser eye surgery?

- A. Retina
- B. Lens
- C. Cornea
- D. Optic nerve
- E. Iris

**Correct Answer: C**

10. What role does wavefront-guided surgery play in laser eye surgery?

- A. Improves blood flow to the eye
- B. Corrects higher-order aberrations for sharper vision
- C. Reduces recovery time significantly
- D. Allows for flap-free procedures
- E. Uses thermal imaging for precision

**Correct Answer: B**

11. What is the primary energy transfer process in laser-tissue interaction during surgery?

- A. Reflection
- B. Absorption and ablation
- C. Refraction
- D. Thermal conduction
- E. Scattering

**Correct Answer: B**

12. What ensures minimal thermal damage during laser eye surgery?

- A. Continuous laser beams
- B. Short pulse duration and cooling systems
- C. High penetration depth
- D. Use of infrared lasers
- E. Low-intensity laser beams

**Correct Answer: B**



**13. What is the primary purpose of the femtosecond laser in LASIK?**

- A. Reshaping the lens
- B. Creating the corneal flap
- C. Ablating corneal tissue
- D. Analyzing wavefront aberrations
- E. Cooling the cornea

**Correct Answer: B**

**14. Which technique has a longer healing time but avoids flap complications?**

- A. LASIK
- B. PRK
- C. SMILE
- D. Cataract surgery
- E. Wavefront-guided surgery

**Correct Answer: B**

**15. Which type of refractive error occurs when light focuses behind the retina?**

- A. Myopia
- B. Hyperopia
- C. Astigmatism
- D. Presbyopia
- E. None of the above

**Correct Answer: B**

**16. What is the approximate ablation depth of an excimer laser pulse?**

- A. 0.1 micrometers
- B. 0.25 micrometers
- C. 1 micrometer
- D. 2 micrometers
- E. 5 micrometers

**Correct Answer: B**

**17. Which type of laser emits ultraviolet light at 193 nm?**

- A. Excimer laser
- B. Femtosecond laser
- C. CO<sub>2</sub> laser
- D. Argon laser
- E. Nd:YAG laser

**Correct Answer: A**

**18. What is a common side effect of laser eye surgery?**

- A. Increased myopia
- B. Dry eyes
- C. Detached retina
- D. Iris damage
- E. Corneal infection

**Correct Answer: B**

**19. Which principle of physics helps achieve precise optical imaging in wavefront-guided surgery?**

- A. Diffraction
- B. Reflection
- C. Wave propagation
- D. Polarization
- E. Dispersion

**Correct Answer: C**

**20. What technology minimizes the risks of laser eye surgery?**

- A. Infrared scanning
- B. AI and adaptive optics
- C. Thermal imaging
- D. Manual adjustments
- E. UV radiation shields

**Correct Answer: B**

**21. What does SMILE stand for?**

- A. Small Incision Lenticule Extraction
- B. Sub-Minimal Intraocular Lens Extraction
- C. Small Mechanical Incision Laser Eye surgery
- D. Selective Minimal Invasive Laser Enhancement
- E. Simplified Method for Improved Lens Extraction

**Correct Answer: A**

**22. What is the primary goal of reshaping the cornea?**

- A. To change the eye's color
- B. To focus light correctly onto the retina
- C. To remove cataracts
- D. To strengthen the corneal tissue
- E. To reduce eye strain

**Correct Answer: B**

**23. Which of the following is NOT a feature of lasers used in surgery?**

- A. Coherence
- B. Collimation
- C. Monochromaticity
- D. High scattering
- E. Precision energy delivery

**Correct Answer: D**

**24. What is the main advantage of wavefront-guided surgery?**

- A. Faster healing time
- B. Correction of higher-order aberrations
- C. Elimination of all refractive errors
- D. Reduced need for follow-up surgery
- E. Completely painless procedure

**Correct Answer: B**

**25. What ensures safety during laser-tissue interaction?**

- A. Beam shaping
- B. Spot size control
- C. Cooling systems
- D. All of the above
- E. None of the above

**Correct Answer: D**