University of Al-Mustaqbal
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Medical Laser Applications

Third Stage

Lec 3

Laser eye surgery

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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.

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.

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.

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** (**PRK** stands for Photo Refractive Keratectomy)

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

PRK (**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.

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.

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.

9. Discussion and Questions (Homework)

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

Discussion

1. What is laser eye surgery?

A. Drug therapy

B. Optical glasses

C. Corneal reshaping

D. Retinal repair

E. Eye transplant

Correct: C

2. Laser eye surgery mainly improves:

A. Color vision

B. Night vision

C. Visual acuity

D. Eye muscles

E. Tear production

Correct: C

3. Which condition is corrected by laser surgery?

A. Cataract

B. Glaucoma

C. Myopia

D. Infection

E. Blindness

Correct: C

4. Myopia occurs when light focuses:

A. On retina

B. Behind retina

C. Before retina

D. Outside eye

E. On cornea

Correct: C

5. Hyperopia occurs when light focuses:

A. On retina

B. Before retina

C. Behind retina

D. On cornea

E. Outside eye

Correct: C

6. Astigmatism is caused by:

A. Retina damage

B. Lens opacity

C. Corneal irregularity

D. Weak muscles

E. Tear loss

Correct: C

7. The main optical elements of the eye are:

A. Retina only

B. Cornea and lens

C. Iris and pupil

D. Sclera only

E. Optic nerve

Correct: B

8. The goal of laser surgery is to:

A. Remove retina

B. Strengthen lens

C. Reshape cornea

D. Change pupil

E. Repair nerve

Correct: C

9. LASER stands for:

A. Light energy radiation

B. Light amplified radiation

C. Light amplification stimulated emission

D. Laser emission system

E. Light emission radiation

Correct: C

10. A key laser property is:

A. Dispersion

B. Coherence

C. Reflection

D. Absorption

E. Refraction

Correct: B

11. Which laser uses UV light?

A. Diode

B. Nd:YAG

C. Excimer

D. CO_2

E. Ruby

Correct: C

12. Excimer laser wavelength is:

A. 1064 nm

B. 800 nm

C. 532 nm

D. 193 nm

E. 10.6 μm

Correct: D

13. Excimer laser action causes:

A. Heating tissue

B. Mechanical cutting

C. Photochemical ablation

D. Electrical stimulation

E. Ionization

Correct: C

14. Ablation depth per pulse is about:

A. 10 µm

B. 5 µm

C. 1 µm

D. 0.25 µm

E. 0.01 µm

Correct: D

15. Which laser creates corneal flaps?

A. Excimer

B. Argon

C. Femtosecond

D. CO_2

E. Helium-Neon

Correct: C

16. Femtosecond lasers use:

A. UV light

B. Visible light

C. Infrared light

D. X-rays

E. Microwaves

Correct: C

17. LASIK first step is:

A. Epithelium removal
B. Corneal flap creation
C. Retina exposure
D. Lens removal
E. Eye dilation
Correct: B

18. PRK differs from LASIK by:

A. Using no laser
B. No flap creation
C. Retina treatment
D. Longer pulses
E. Thermal cutting
Correct: B

19. PRK is preferred for:

A. Thick corneas
B. Thin corneas
C. Cataracts
D. Glaucoma
E. Retina disease
Correct: B

20. Wavefront-guided surgery corrects:

A. Refraction only
B. Color vision
C. Higher-order aberrations
D. Eye pressure
E. Tear flow
Correct: C

21. Beam shaping improves:

A. Safety only

B. Spot control

C. Eye pressure

D. Blood flow

E. Pupil size

Correct: B

22. Minimal thermal damage is due to:

A. Long pulses

B. High temperature

C. Short pulses

D. Deep penetration

E. Continuous beams

Correct: C

23. A common side effect is:

A. Infection

B. Blindness

C. Dry eyes

D. Retina detachment

E. Eye tumors

Correct: C

24. Laser surgery is NOT suitable for:

A. Myopia

B. Astigmatism

C. Thin corneas

D. Refractive errors

E. Normal eyes

Correct: C

25. Laser eye surgery combines physics of:

A. Thermodynamics only

B. Mechanics only

C. Optics and lasers

D. Electricity only

E. Nuclear physics

Correct: C