University of Al-Mustaqbal
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Dep. Medical physics

Medical Laser Applications

Third Stage

Lec 4

Types Of Techniques Used

In

Eye Surgery

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Introduction

The field of eye surgery, or ophthalmology, has advanced significantly over the years with the integration of physics-based techniques. The human eye, being a highly sensitive and intricate organ, requires precise and minimally invasive methods for effective treatment. Physics plays a vital role in understanding and implementing these techniques, particularly in areas such as optics, lasers, and material science.

This lecture will discuss the major types of techniques used in eye surgery, focusing on the underlying physics principles.

1. Refractive Surgery Techniques

Refractive surgery is aimed at correcting vision problems such as myopia, hyperopia, and astigmatism by reshaping the cornea.

a) LASIK (Laser-Assisted In Situ Keratomileusis):

- **How It Works:**
  - A femtosecond laser creates a thin flap on the cornea.
  - An excimer laser reshapes the corneal stroma to correct the refractive error.
  - The flap is repositioned.
- **Physics Principle:**
  - The excimer laser uses **UV** light to break molecular bonds in the cornea (photoablation) with high precision, without generating heat.

b) PRK (Photorefractive Keratectomy):

- **How It Works:**
  - The epithelial layer is removed.
  - An excimer laser reshapes the cornea directly.
- **Physics Principle:**
  - Similar to LASIK, it relies on photoablation to sculpt the corneal surface.

c) SMILE (Small Incision Lenticule Extraction):

- **How It Works:**
  - A femtosecond laser creates a lenticule (thin disc) within the cornea.
  - The lenticule is removed through a small incision.
- **Physics Principle:**
  - Femtosecond laser pulses generate micro-cavitation to create precise incisions.

2. Cataract Surgery Techniques

Cataracts involve clouding of the natural lens, and surgery replaces it with an artificial intraocular lens (**IOL**) .

*The term (**IOL**) stands for **Intraocular Lens**. It is an artificial lens implanted in the eye to replace a natural lens that has been removed, often during cataract surgery.*

a) Phacoemulsification:

- **How It Works:**
  - Ultrasound waves break the cloudy lens into small pieces.
  - The pieces are suctioned out, and an (**IOL**) is implanted.

- **Physics Principle:**
    - Ultrasonic vibrations (high-frequency sound waves) cause the lens material to emulsify, using cavitation and mechanical forces.

b) Femtosecond Laser-Assisted Cataract Surgery (FLACS):

- **How It Works:**
    - A femtosecond laser makes precise incisions in the cornea and softens the lens.
    - This enhances the precision of IOL placement.
- **Physics Principle:**
    - Laser pulses interact with tissue via plasma-mediated ablation, minimizing collateral damage.

3. Retinal Surgery Techniques

Retinal surgeries address conditions like retinal detachment, diabetic retinopathy, and macular holes.

a) Vitrectomy:

- **How It Works:**
    - The vitreous gel is removed and replaced with a gas bubble or silicone oil.
- **Physics Principle:**
    - Fluid dynamics governs the replacement process to ensure stability of the retina.

b) Laser Photocoagulation:

- **How It Works:**
    - A laser creates small burns on the retina to seal tears or reduce abnormal blood vessels.
- **Physics Principle:**
    - The focused laser light delivers energy to coagulate tissue, using thermal effects.

4. Glaucoma Surgery Techniques

Glaucoma involves increased intraocular pressure, which can damage the optic nerve.

a) Trabeculectomy:

- **How It Works:**
  - A small flap is created in the sclera to drain excess fluid.
- **Physics Principle:**
  - Fluid mechanics dictates the controlled drainage of aqueous humor.

b) Laser Trabeculoplasty:

- **How It Works:**
  - A laser is used to open the drainage canals in the trabecular meshwork.
- **Physics Principle:**
  - The laser delivers thermal energy to induce structural changes and improve fluid outflow.

5. Corneal Transplantation

Corneal transplants replace a damaged cornea with donor tissue.

a) DSAEK (Descemet's Stripping Automated Endothelial Keratoplasty):

- **How It Works:**
  - A thin layer of donor tissue is transplanted.
- **Physics Principle:**
  - Requires precise surgical tools to maintain optical clarity and structural integrity.

b) Corneal Cross-Linking:

- **How It Works:**
  - UV light activates a riboflavin solution to strengthen the cornea.
- **Physics Principle:**
  - Photochemical reactions lead to cross-linking of collagen fibers, increasing biomechanical strength.

6. Emerging Techniques

- **a) Wavefront-Guided LASIK:**
  - Customizes corneal reshaping using wavefront aberrometry.
  - **Physics:** Involves advanced optics and interference patterns.
- **b) Robotic-Assisted Surgery:**
  - Enhances precision using robotics and computer guidance.
  - **Physics:** Relies on motion tracking and mechanical systems.

Conclusion

Physics forms the backbone of modern eye surgery techniques, enabling precision and safety. From lasers and ultrasound to fluid dynamics and photochemical processes, advancements in this field continue to push the boundaries of what is possible in ophthalmology.

Discussion

1. What does refractive surgery primarily correct?

A) Vision errors

B) Retina tears

C) Cataracts

D) Eye infections

E) Optic nerve

Correct answer: A

2. Which eye part is reshaped in refractive surgery?

A) Retina

B) Lens

C) Cornea

D) Sclera

E) Iris

Correct answer: C

3. LASIK flap is created using which laser?

A) Excimer

B) CO_2

C) Diode

D) Femtosecond

E) Argon

Correct answer: D

4. Which laser reshapes corneal stroma in LASIK?

A) Nd:YAG

B) Excimer

C) Diode

D) Argon

E) Ruby

Correct answer: B

5. Excimer laser works mainly by:

A) Heating tissue

B) Photoablation

C) Ionization

D) Compression

E) Reflection

Correct answer: B

6. Which surgery removes corneal epithelium first?

A) LASIK

B) SMILE

C) PRK

D) FLACS

E) DSAEK

Correct answer: C

7. SMILE surgery removes a:

A) Flap

B) Lens

C) Epithelium

D) Retina

E) Lenticule

Correct answer: E

8. SMILE uses which laser pulses?

A) Continuous

B) Infrared

C) UV

D) Femtosecond

E) Microwave

Correct answer: D

9. Micro-cavitation is produced by:

A) Ultrasound

B) Heat

C) Pressure

D) Femtosecond laser

E) X-rays

Correct answer: D

10. Cataract surgery replaces which structure?

A) Cornea

B) Retina

C) Natural lens

D) Optic nerve

E) Iris

Correct answer: C

11. IOL stands for:

A) Internal optic layer

B) Intraocular lens

C) Infra-optic light

D) Implantable optic line

E) Internal ocular liquid

Correct answer: B

12. Phacoemulsification uses:

A) Laser light

B) UV radiation

C) Ultrasound waves

D) Electric current

E) Microwaves

Correct answer: C

13. Lens breakdown in phacoemulsification is due to:

A) Diffraction

B) Reflection

C) Interference

D) Polarization

E) Cavitation

Correct answer: E

14. FLACS improves mainly:

A) Eye color

B) Retina focus

C) IOL precision

D) Tear production

E) Pupil size

Correct answer: C

15. Plasma-mediated ablation occurs in:

A) PRK

B) LASIK

C) Vitrectomy

D) FLACS

E) DSAEK

Correct answer: D

16. Vitrectomy removes the:

A) Vitreous gel

B) Cornea

C) Lens

D) Retina

E) Iris

Correct answer: A

17. Retina stability after vitrectomy depends on:

A) Optics

B) Fluid dynamics

C) Heat transfer

D) Diffusion

E) Reflection

Correct answer: B

18. Laser photocoagulation uses mainly:

A) Mechanical force

B) Chemical reaction

C) Thermal effects

D) Ultrasound

E) Magnetic fields

Correct answer: C

19. Glaucoma is caused by increased:

A) Blood flow

B) Eye pressure

C) Light intensity

D) Lens opacity

E) Tear volume

Correct answer: B

20. Trabeculectomy drains:

A) Blood

B) Vitreous

C) Aqueous humor

D) Tears

E) Plasma

Correct answer: C

21. Fluid drainage control follows:

A) Quantum theory

B) Thermodynamics

C) Acoustics

D) Optics

E) Fluid mechanics

Correct answer: E

22. Laser trabeculoplasty improves:

A) Fluid outflow

B) Corneal shape

C) Vision color

D) Retina focus

E) Tear ducts

Correct answer: A

23. DSAEK replaces which corneal layer mainly?

A) Epithelium

B) Stroma

C) Tear film

D) Bowman's layer

E) Endothelium

Correct answer: E

24. Corneal cross-linking uses UV and:

A) Saline

B) Alcohol

C) Riboflavin

D) Silicone

E) Lidocaine

Correct answer: C

25. Wavefront-guided LASIK is based on:

A) Advanced optics

B) Magnetism

C) Acoustics

D) Nuclear physics

E) Fluid flow

Correct answer: A