Learning Objectives

A. List neighboring anatomical regions and structures related to each wall of the orbit.

B. Describe the fascial structures of the orbit, and their relationships to the bones, eyelids, and eyeball.

C. List the layers of the eyelids; describe the conjunctiva of the eyelids & eyeball, and name the nerves that provide sensory innervation to the eyelid skin and related conjunctiva.

D. Trace the pathways of the motor neurons coursing through the oculomotor, trochlear, and abducent nerves.

E. Trace the pathways of the sensory neurons that innervate bulbar conjunctiva as opposed to the palpebral conjunctiva and skin of the eyelids.

F. Discuss the function and describe the pathways for sympathetics and parasympathetics to smooth muscles of the orbit.

G. Describe the afferent and efferent pathways involved in the corneal and pupillary reflexes including the location of the neuronal cell bodies.

H. Diagram the arrangement of extraocular muscles within the orbit, give their innervation, and describe their anatomical actions.
• **Relationships of the orbit**

• Arrangement of orbital contents (fascial structures)

• Structure of eyelids & lacrimal apparatus

• Cranial nerves of the orbit (CN II-VII)

• Autonomics of the orbit (para & symp)

• Arrangement & anatomical action of extraocular muscles

• Clinical testing of extraocular muscles
Anterior cranial fossa

Ethmoid air cells

Frontal sinus

Maxillary sinus

Nasal cavity

Frontal Section through Orbit

General Relationships of the Orbit

Anteroposterior Radiograph
Lecture Outline

• Relationships of the orbit
• Arrangement of orbital contents (fascial structures)
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• Blood supply to the orbit
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Dura mater lining the cranial cavity has two layers:

- Periosteal
- Meningeal
**General Arrangement of Orbital Fascia & Fat**

- Periosteum
- Orbital septum
- Superior tarsal plate
- Inferior tarsal plate
- Optic nerve
- Fat
- Periorbita (periosteum)
- Optic sheath:
  - Arachnoid
  - Pia
- Dura
- Bilaminar intracranial dura
- Orbital septum
- Tarsal plates
- Optic canal
Structure of the Eyelids

Five layers of eyelids
1. Skin
2. Subcutaneous layer
3. Muscular layer (2)
4. Tarsofascial layer (3)
5. Conjunctival layer
Clinical correlate: eye infections

The pictures below show inflammations of different structures related to the eyelids. Which structure is involved in each case?

- **Stye** (hordeolum externum)
- **Conjunctivitis** (pinkeye)
- **Chalazion** (hordeolum internum)

Sebaceous glands
Conjunctiva
Tarsal glands
Lacrimal apparatus

Lacrimal gland produces tears → pass from lacrimal duct, across surface of eye to lacrimal canaliculi → take tears from lacrimal lake to lacrimal sac down nasolacrimal duct to nasal cavity

Lacrimal gland (CN VII)

Lacrimal lake

Lacrimal canaliculus

Lacrimal lake: pinkish shallow reservoir of tears medial canthus
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The blood supply to the orbit and eye is via the ophthalmic artery:
Papilledema with hemorrhage

Normal

CSF
Venous drainage from the orbit communicates with facial vein anteriorly and cavernous sinus posteriorly. **These veins have no valves**

**Cavernous sinus thrombosis**

- Cavernous sinus
- Superior ophthalmic vein
- Facial vein

**Danger area**
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Cranial nerves related to the orbit

- Optic (II)
- Oculomotor (III)
- Trochlear (IV)
- Trigeminal (V)
  - Ophthalmic ($V_1$)
  - Maxillary ($V_2$)
- Abducent (VI)
3 Cranial nerves innervate extraocular muscles

- Trochlear (IV)
- Oculomotor (III)
- Abducent (VI)

CN II

CN V₁

CN V₂

CN V₃
Motor Innervation of Extraocular Muscles

- Motor axons
- Oculomotor (III)
- Trochlear (IV)
- Abducent (VI)
- Trigeminal (V)
- Abducent nucleus
- Trochlear nucleus

- Superior orbital fissure
- Nasociliary n.
- Long ciliary n.
- Ciliary nerves
- Short ciliary n.
- Ciliary ganglion
- Inferior rectus m.
- Medial rectus m.
- Inferior oblique m.
- Lateral rectus m.

- Levator palpebrae m.
- Superior rectus m.
- Superior oblique m.

- Internal carotid artery
- Cavernous sinus

- Motor Innervation of Extraocular Muscles
Summary of Extraocular Muscle Innervation

Handy mnemonic: \( \text{LR}_6 \text{SO}_4 \text{AO}_3 \)
(Lateral Rectus CN VI, Superior Oblique CN IV, All Others CN III)
Sensory innervation to the orbit

→ Branches of Trigeminal n. (CN V)
  mostly V₁ – Ophthalmic
  some V₂ – Maxillary

V₁ sensory to:
1. skin upper eyelid
2. Bulbar conjunctiva
3. Palpebral conjunctiva (upper eyelid)

V₂ sensory to:
1. skin lower eyelid
2. Palpebral conjunctiva (lower eyelid)
Sensory components of ophthalmic & maxillary nerves

*Corneal (blink) reflex (blinking caused by light touching of the cornea):
  afferent limb = CN V₁ from cornea via ciliary nerves
  efferent limb = CN VII to orbicularis oculi
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Zonular fibers attach to lens from ciliary muscle.

**Smooth muscles of the eye**

- **Dilator pupillae m.** *(sympathetic)* – dilates pupil
- **Ciliary muscle** *(parasymp)* – controls thickness of lens *(accommodation/focus)*
- **Sphincter pupillae m.** *(parasympathetic)* – constricts pupil
Parasympathetic components of oculomotor n.

**Ciliary ganglion**: collection of parasympathetic post-ganglionic cell bodies.

The pupillary light reflex involves this pathway to the sphincter pupillae muscle.
*Pupillary light reflex* (constriction of pupil in response to light shone in pupil): afferent limb = CN II from stimulation of retinal ganglion cells; efferent limb = CN III (para) via ciliary nerves to pupillary sphincter.
Sympathetic innervation to orbit

TO HEAD

Symp (dilator pupillae & superior tarsal)

Levator palpebrae superioris

Superior tarsal muscle

Dilator pupillae muscle

Lateral gray column of upper thoracic spinal cord
Sympathetic innervation to orbit...

- Oculomotor (III)
- CN IV
- CN VI
- CN V
- Carotid plexus
- Superior cervical sympathetic ganglion
- Superior tarsal m.
- Levator palpebrae m.
- Sympathetic pathway
- Long ciliary n.
- Short ciliary nn.
- Ciliary nn.
- Ciliary ganglion
- Dilator pupillae m.
- Ciliary muscle
- Sphincter pupillae m.
Summary: Autonomics to orbit

**Parasympathetics** (via cranial nerves) to:
- lacrimal gland
- sphincter pupillae m.
- ciliary m.

**Sympathetics** (via carotid plexuses) to:
- blood vessels
- superior tarsal m.
- dilator pupillae m.
Clinical correlate: Horner’s Syndrome

What are the signs in this patient that there is an interruption of sympathetic innervation to the head?

1. Ptosis (droopy upper eyelid) ↔ paralysis of superior tarsal muscle

2. Miosis (constricted pupil) ↔ paralysis of dilator pupillae muscle because no resistance to parasympathetically controlled pupillary sphincter

3. Vasodilation (flushed, warm skin) ↔ paralysis of smooth muscle in walls of vessels

4. Anhydrosis (dry skin due to lack of perspiration) ↔ sweat glands denervated

Patient with right-side Horner’s syndrome

“Sahara dessert syndrome”
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Anatomical arrangement, innervation, & function of extraocular muscles
Movements of the Eyeball
Extraocular Muscles

The key to learning and retaining knowledge of how the 6 extraocular muscles move the eyeball is to visualize each muscle’s anatomical position relative to two axes (horizontal and vertical) using simple line drawings.

Right orbit seen from above

IO = inferior oblique
IR = inferior rectus
LR = lateral rectus
MR = medial rectus
SO = superior oblique
SR = superior rectus
Superior Rectus Muscle: Anatomical Actions

When SR contracts relative to horizontal axis, cornea moves upward (**ELEVATION**). SR passes medial to vertical axis.

When SR contracts relative to vertical axis, the cornea moves medially (**ADUCTION**).
When IR contracts relative to horizontal axis, it rotates cornea downward (**DEPRESSION**).

When IR rectus contracts relative to vertical axis, it rotates cornea medially (**ADDUCTION**).
Inferior Oblique: Anatomical Actions

When IO contracts relative to horizontal axis, it rotates back half of eyeball down causing cornea to rotate upward (**ELEVATION**).

When IO contracts relative to vertical axis, it rotates back of eyeball medially causing cornea to rotate laterall (**ABDUCTION**).
**Superior Oblique: Anatomical Actions**

When SO contracts relative to horizontal axis, it rotates back of eye forward making cornea rotate downward (**DEPRESSION**).

When SO contracts relative to vertical axis, it rotates back of the eye medially causing cornea to rotate outward (**ABDUCTION**).
**Learning Tip:** Learning whether a muscle abducts or adducts relative to vertical axis is made easier by realizing that the tendons for all muscles but lateral rectus pass on medial side of the vertical axis.

This is critical to drawing, or imagining, the correct positions of muscles relative to the vertical axis.
Summary Movements Relative to Vertical Axis

**ADDUCTORS:**
- Superior rectus
- Inferior rectus
- Medial rectus

**ABDUCTORS:**
- Superior oblique
- Inferior oblique
- Lateral rectus
Summary Movements Relative to Horizontal Axis

ELEVATORS:
- Superior rectus
- Inferior oblique

DEPRESSIONS:
- Superior oblique
- Inferior rectus
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Clinical Testing of Extraocular Muscles

In terms of peripheral nerve lesions that affect extraocular movements, there are three possibilities, **oculomotor (III)**, **trochlear (IV)** and **abducent (VI)**.

Since a lesion of **CNIII** includes a dilated (blown) pupil, plus a ptosis, plus a loss of many eye movements, it is typically not necessary to test each of the muscles innervated by CNIII in order to make this diagnosis.

A lesion of **CNVI (abducent)** results in paralysis of the lateral rectus with the patient having difficulty looking laterally, an easy condition to assess clinically.

However, a lesion of **CNIV (trochlear)** requires testing the superior oblique muscle in order to make a diagnosis. Therefore, the following demonstrates how one clinically assesses the superior oblique.
The superior oblique and the inferior rectus are the only two muscles that can depress the eye (relative to the horizontal axis).

How can one isolate and test this action for the SO while eliminating any contribution from the inferior rectus?

First, have the patient adduct the eye as far as possible without looking up or down (medial rectus does this).

Notice how the horizontal axis also rotated with the adducted eye, making it now nearly parallel to IR.

In this adducted position, only the SO muscle, whose line of pull is perpendicular to the horizontal axis, can depress the eye if it is innervated by IV; the IR cannot depress the eye since it is parallel to horizontal axis.
Question?

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