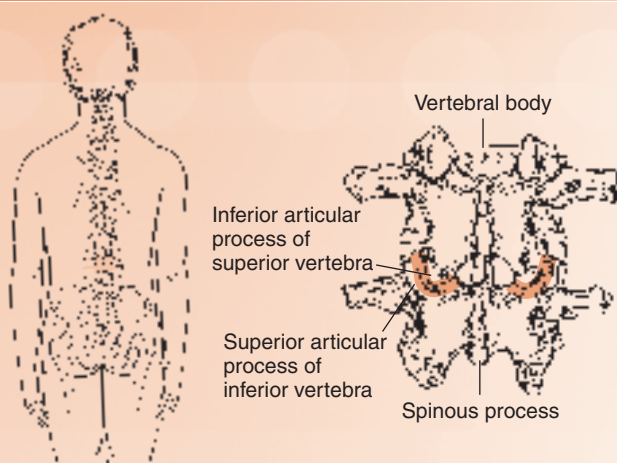


PART



Kinesiology of the Head and Spine



UNIT 4: MUSCULOSKELETAL FUNCTIONS WITHIN THE HEAD

- Chapter 20: Mechanics and Pathomechanics of the Muscles of the Face and Eyes
- Chapter 21: Mechanics and Pathomechanics of Vocalization
- Chapter 22: Mechanics and Pathomechanics of Swallowing
- Chapter 23: Structure and Function of the Articular Structures of the TMJ
- Chapter 24: Mechanics and Pathomechanics of the Muscles of the TMJ
- Chapter 25: Analysis of the Forces on the TMJ during Activity

UNIT 5: SPINE UNIT

- Chapter 26: Structure and Function of the Bones and Joints of the Cervical Spine
- Chapter 27: Mechanics and Pathomechanics of the Cervical Musculature
- Chapter 28: Analysis of the Forces on the Cervical Spine during Activity
- Chapter 29: Structure and Function of the Bones and Joints of the Thoracic Spine
- Chapter 30: Mechanics and Pathomechanics of the Muscles of the Thoracic Spine
- Chapter 31: Loads Sustained by the Thoracic Spine
- Chapter 32: Structure and Function of the Bones and Joints of the Lumbar Spine
- Chapter 33: Mechanics and Pathomechanics of Muscles Acting on the Lumbar Spine
- Chapter 34: Analysis of the Forces on the Lumbar Spine during Activity
- Chapter 35: Structure and Function of the Bones and Joints of the Pelvis
- Chapter 36: Mechanics and Pathomechanics of Muscle Activity in the Pelvis
- Chapter 37: Analysis of the Forces on the Pelvis during Activity

UNIT 4

MUSCULOSKELETAL FUNCTIONS WITHIN THE HEAD

The preceding three units examine the structure, function, and dysfunction of the upper extremity, which is part of the appendicular skeleton. Since the function of the remaining appendicular skeleton, the lower extremities, is so intimately related to the spine, it is necessary first to investigate the spine, which is part of the axioskeleton. The axioskeleton includes the head and spine, and this text begins its examination of the axioskeleton at the head and proceeds in a caudal direction. The current unit examines the function and dysfunction of the musculoskeletal components of the head. These structures work in concert with each other in diverse functions including facial expression, vocalization, chewing, and swallowing. This unit is divided rather artificially by function, and the structures most associated with each function are described within the context of that function. However, the reader must recognize that many anatomical components participate in multiple functions. For example, the lips participate in facial expressions, chewing, and speech, and the tongue is equally important in swallowing and speech.

The first three chapters of this unit deviate slightly from the organization used in other parts of this textbook because they focus on the overall functions of facial expression, vocalization, and swallowing. The structure of bones and joints plays a smaller role in the understanding of these functions, so the chapters present a less detailed review of the relevant anatomical structures. Although plastic surgeons require a detailed knowledge of the structures within the face, and otolaryngologists and speech and language specialists need a more detailed understanding of the larynx and pharynx, conservative management of functional deficits is typically based on more-global assessments of impairments in these activities, and few individuals are able to isolate single muscles throughout the face, mouth, and throat. Therefore, each of the next three chapters presents a discussion of the role of the muscles participating in the specified function. The purposes of the first three chapters are to

- Examine the muscles that move the face and eyes (Chapter 20)
- Describe the intrinsic muscles of the larynx and discuss the mechanics of voice production (Chapter 21)
- Review the muscles of the mouth and pharynx and discuss the sequence of movements that constitute the swallow (Chapter 22)

Chapters 23 through 25 in this unit focus on the temporomandibular joint, in which a more detailed understanding of the skeletal, articular, and muscular components is necessary to understand the function and dysfunction of the joint. Consequently, these chapters return to the organization used in most of this text. The purposes of the last three chapters of this unit are to

- Present the bony and articular structures of the temporomandibular joint and describe the motions that occur (Chapter 23)
- Review the muscles of mastication and their contribution to chewing (Chapter 24)
- Review the forces sustained by the temporomandibular joints under various conditions (Chapter 25)

CHAPTER

20

Mechanics and Pathomechanics of the Muscles of the Face and Eyes

CHAPTER CONTENTS

DISTRIBUTION OF THE FACIAL NERVE	391
MUSCLES INNERVATED BY THE FACIAL NERVE	392
Muscles of the Scalp and Ears	393
Facial Muscles Surrounding the Eyes	395
Muscles of the Nose	397
Muscles of the Mouth	399
MUSCLES THAT MOVE THE EYES	406
SUMMARY	410

The muscles of the face are small and superficial, attaching at least in part to the skin of the face. The resulting skin movement is an essential part of human communication, allowing a face to express love, rage, sadness, fear, and a multitude of other human emotions [14,20,23].

Human expression is enhanced by movements of the eyes, such as when an individual rolls the eyes in disgust. Appropriate and coordinated eye movement also is critical to clear and accurate vision. This chapter presents the muscles that produce facial and ocular movements and discusses the dysfunctions resulting from pathology affecting these muscles. The specific purposes of this chapter are to

- Present the muscles of facial expression
- Discuss the movement dysfunctions that result from weakness in these muscles
- Describe the muscles that move the eyes
- Discuss the coordination of the eye muscles that produces smooth eye movements essential for proper vision

DISTRIBUTION OF THE FACIAL NERVE

The muscles of facial expression are innervated by the motor branch of the seventh cranial nerve, known as the facial nerve (*Fig. 20.1*). As it emerges from the stylomastoid foramen of the temporal bone, the facial nerve gives off a branch, the posterior auricular nerve, to the occipitalis and the posterior auricularis muscle. The terminal portion of the facial

nerve, lying within the parotid gland, divides into several branches that go on to supply the rest of the muscles of facial expression:

- The temporal branch supplies the anterior and superior auricular muscles and the frontalis, orbicularis oculi, and corrugator muscles.
- The zygomatic branch supplies the lateral portions of the orbicularis oculi.

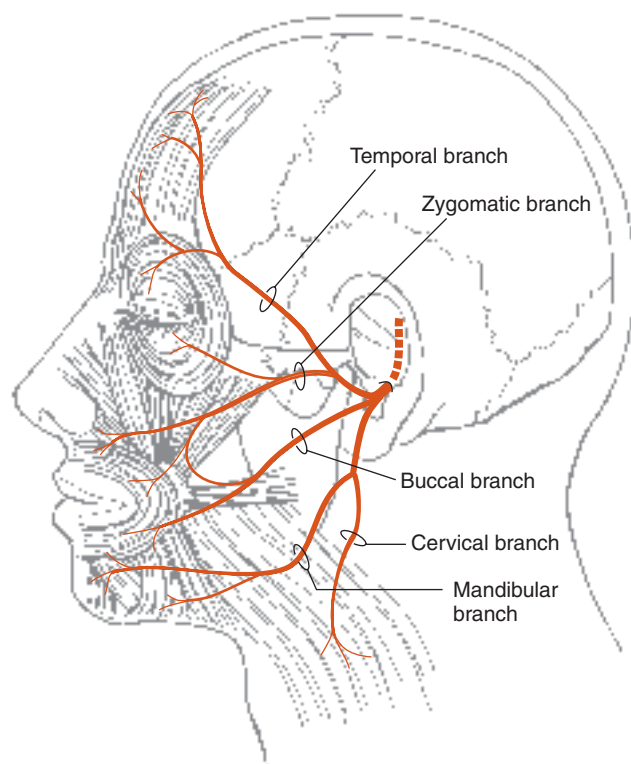


Figure 20.1: The facial nerve gives off the posterior auricular nerve, and then its terminal portion divides into several branches: temporal, zygomatic, buccal, mandibular, and cervical.

- The buccal branch innervates the muscles of the nose and the zygomaticus, levator labii superioris, levator anguli oris, orbicularis oris, and buccinator.
- The mandibular branch supplies the muscles of the lower lip and the mentalis.
- The cervical branch supplies the platysma.



An understanding of the organization of the facial nerve helps the clinician recognize and evaluate the clinical manifestations of facial nerve palsies.

MUSCLES INNERVATED BY THE FACIAL NERVE

Most of the muscles innervated by the facial nerve are **muscles of facial expression**, unique because they cross no joints and attach to aponeuroses and, directly or indirectly, to the skin of the face, producing movement of the facial skin [39,50,51]. There are approximately 21 pairs of muscles in the face. However, asymmetry in movements produced by individual muscles within a pair is common among healthy individuals [13,30,36,44]. Consequently, clinicians must be cautious when determining the clinical significance of asymmetrical facial excursion. For example, many individuals can raise one eyebrow but not the other [13]. The inability to raise an eyebrow may reflect a common lack

of motor control or may be the manifestation of muscle weakness. The clinician requires additional evidence before determining that a muscle is weak. Such corroborating evidence includes the function of surrounding muscles, the resting posture of the face, and the condition of the facial skin.

Clinical Relevance

FACIAL CREASES: As noted in Chapter 17, most normal skin creases are formed by the pull of underlying muscles that lie perpendicular to the creases. Most facial creases are the consequence of activity of the facial muscles that lie just underneath the skin. Because facial creases are the superficial manifestations of muscle activity under the skin, the absence of facial creases in an adult may indicate weakness in underlying facial muscles. The clinician must be cautious to avoid interpreting the smooth, unlined skin of an elder patient as the consequence of a lifetime of good skin care when it may actually indicate muscular weakness. Careful observation of the wrinkles of both sides of the face allows the clinician to recognize asymmetrical wrinkle patterns that may indicate asymmetrical muscle performance and possible pathology. Since individual palpation of single muscles is impossible, inspection of these facial wrinkles is an important component of an assessment of the facial muscles.

The muscles of facial expression surround the **orifices** of the face, regulating their **apertures**, and pull on the skin, thereby modifying facial expressions. The functions of the muscles of facial expression are less well studied than that of the muscles in the limbs and spine. The classic understanding of these muscle actions is reported in standard anatomy texts, which are cited in the discussions that follow [39,51]. However, there is a growing body of literature describing the activity of facial muscles by using electromyography (EMG) to examine the participation of these muscles in facial movements, and these studies also are cited in the following discussions [22,55].

Many of the muscles of the face attach to each other and, therefore, participate together in facial movements. Other muscles, although anatomically separated, appear to function together routinely in certain expressions [40]. The remarkably coordinated contractions of the zygomaticus major, a muscle of the mouth, and the orbicularis oculi, the muscle surrounding the eye, during a smile suggests that these two muscles may even share a common innervation. Other muscles also appear to function in synergies to produce facial expressions that involve most of the face.

Few people can voluntarily contract all of the muscles of the face individually [4]. Unlike most of the muscles of the upper and lower extremities, the muscles of facial expression cannot be assessed individually through palpation or manual muscle testing. Not only do they rarely contract in isolation, they are too small and close together to be palpated. Neely

and Pomerantz report the use of a force transducer to assess the strength of facial movements but individual muscles cannot be isolated [34]. The load transducer measurements indicate that movements about the eye and lips can withstand less than one pound of force applied through the transducer.

Since individual muscles cannot be palpated or tested separately, the clinician must assess the muscle's performance during function, that is, by examining the individual's facial function. Therefore, this text groups the muscles together according to the region of the face affected by their contractions. The discussion includes the actions performed by the muscles and the emotional expressions typically associated with the muscle activity. Weakness of these muscles affects facial expressions and facial wrinkles and also has an impact on functional activities such as chewing and speech. The clinical manifestations of weakness are discussed with each muscle.

Muscles of the Scalp and Ears

The muscles of the scalp and ears include the frontalis, occipitalis, and the auricularis anterior, posterior and superior (Fig. 20.2). Only the frontalis has a visible and reliable contribution to emotional expression, yet all four muscles may be activated during looks of surprise [3].

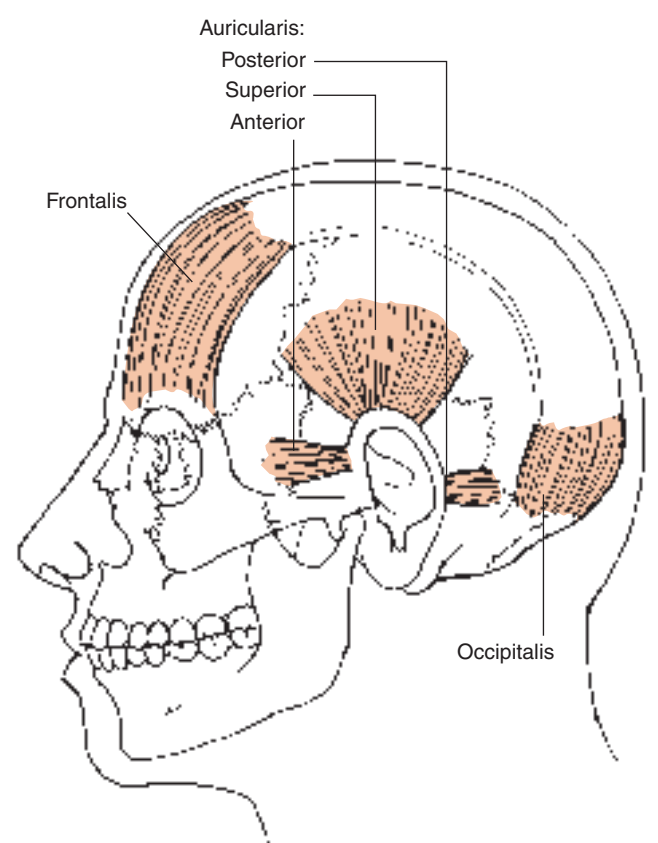


Figure 20.2: The muscles of the scalp and ears include the occipitofrontalis and the auriculares superior, posterior, and anterior.



MUSCLE ATTACHMENT BOX 20.1

ATTACHMENTS AND INNERVATION OF THE OCCIPITOFRONTALIS

Bony/fascial attachment:

Occipitalis: Lateral two thirds of superior nuchal line on the occiput, the mastoid process of the temporal bone, and the epicranial (galea) aponeurosis

Frontalis: Epicranial (galea) aponeurosis

Soft tissue attachment: Skin of the occipital and frontal regions

Innervation:

Occipitalis: Posterior auricular branch of facial nerve

Frontalis: Temporal branches of facial nerve (7th cranial nerve)

FRONTALIS AND OCCIPITALIS

The frontalis and occipitalis actually are the anterior and posterior muscle bellies of a single muscle, the occipitofrontalis, although they are frequently listed separately and can function independently of one another [3,26] (*Muscle Attachment Box 20.1*). They are separated by the galea aponeurotica, which is a large fibrous sheet covering the cranium. The action of the frontalis portion of the muscle is more observable and is the portion typically evaluated clinically.

Actions

MUSCLE ACTION: FRONTALIS

Action	Evidence
Lift eyebrows	Supporting

MUSCLE ACTION: OCCIPITALIS

Action	Evidence
Pull the scalp posteriorly	Supporting

The reported action of the frontalis is to lift the eyebrows. By lifting the eyebrows, the frontalis contributes to a look of surprise [3,36,50]. It also pulls the galea aponeurotica forward, creating the horizontal wrinkles in the forehead. The occipitalis pulls the galea aponeurotica posteriorly, thereby stabilizing it against the pull of the frontalis. The occipitalis also is active in smiling and yawning, although its functional significance is unclear [3].

Weakness

Weakness of the occipitofrontalis is manifested in weakness of the frontalis portion, which limits or prevents the ability to raise the eyebrows. Consequently, the eyebrows are somewhat drooped, stretching the skin of the forehead and reducing or

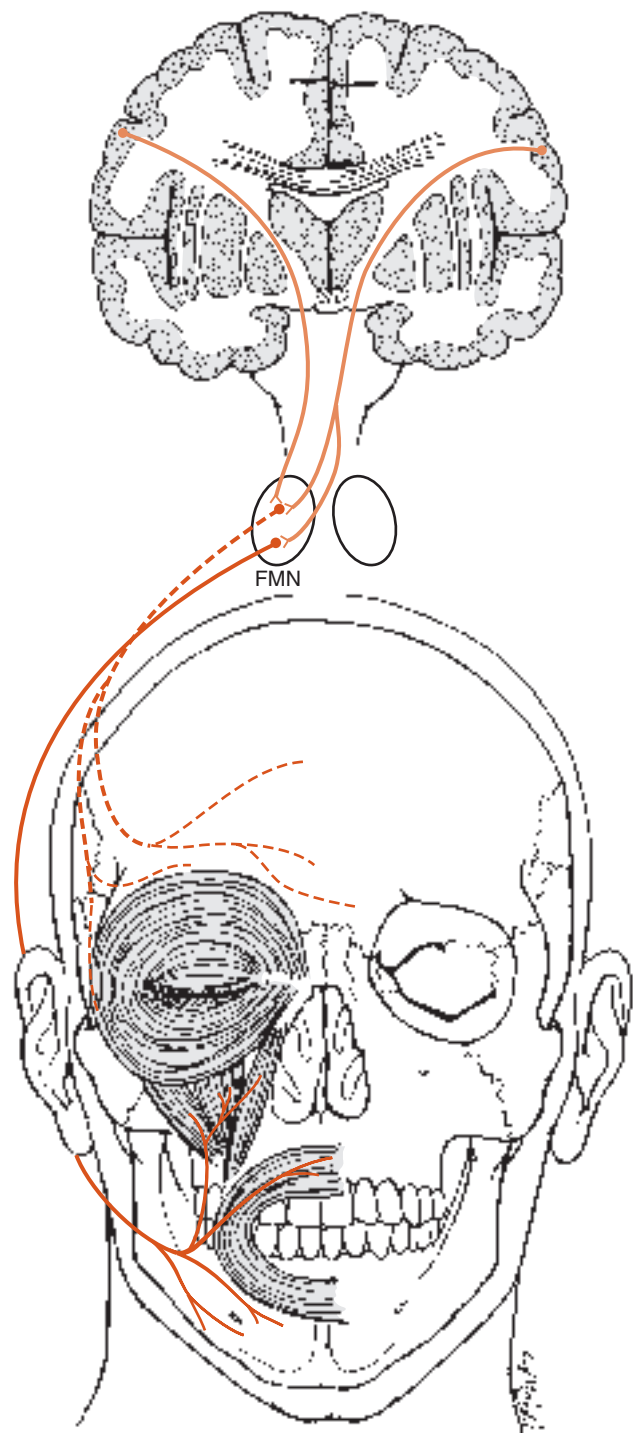


Figure 20.3: The frontalis and part of the orbicularis oculi receive contributions from both hemispheres of the motor cortex, unlike the rest of the facial muscles and most muscles of the body, which receive contributions only from the contralateral hemisphere.



Figure 20.4: A facial nerve palsy produces weakness of the frontalis because the nerve, albeit with input from both hemispheres, does not carry the stimulus to the muscle.

eliminating the forehead wrinkles. When weakness of the frontalis is suspected, careful inspection of the forehead for the presence or absence of wrinkles helps the clinician determine the muscle's integrity.

Weakness of the frontalis is an important clinical finding that helps clinicians distinguish between **upper** and **lower motor neuron lesions** [5]. Most muscles are innervated by nerves that are supplied by the contralateral motor cortex of the brain [31]. The frontalis and part of the orbicularis oculi, however, receive input from the motor cortex of both the contralateral and ipsilateral hemispheres via the temporal branch of the facial nerve through synapses in the facial motor nucleus (FMN) [5,51,52] (Fig. 20.3). As a result, a central nervous system disorder such as a cerebral vascular accident (CVA) that affects the motor cortex of one hemisphere may produce weakness of all of the muscles of facial expression except the frontalis, which is only mildly affected since it still receives input from the ipsilateral hemisphere. In contrast, a lower motor neuron lesion to the facial nerve produces weakness in all of the facial muscles including the frontalis, since the facial nerve is the final common pathway to the muscles of facial expression (Fig. 20.4). Facial weakness with sparing of the frontalis suggests an upper motor neuron lesion, while facial weakness including the frontalis suggests a lower motor neuron lesion.

AURICULARES ANTERIOR, SUPERIOR, AND POSTERIOR

The auriculares muscles are much less developed in humans than in animals who rotate their ears to localize the sounds of prey or predators (*Muscle Attachment Box 20.2*).

Action

MUSCLE ACTION: AURICULARES

Action	Evidence
Wiggle the ears	Inadequate

**MUSCLE ATTACHMENT BOX 20.2****ATTACHMENTS AND INNERVATION OF THE AURICULARES****Bony/fascial attachment:**

Anterior: Temporal fascia and epicranial aponeurosis

Superior: Epicranial aponeurosis and temporal fascia

Posterior: Surface of the mastoid process of the temporal bone

Soft tissue attachment:

Anterior: Cartilage of the ear

Superior: Cartilage of the ear

Posterior: Cartilage of the ear

Innervation: Posterior auricular and temporal branches of facial nerve (7th cranial nerve)

The theoretical action of the auriculares muscles is to wiggle the ears. In a study of 442 university students, approximately 20% exhibited the ability to move either ear, and slightly less than 20% could move both ears simultaneously [13]. Evaluation of the auriculares muscles is not clinically relevant.

Facial Muscles Surrounding the Eyes

The facial muscles affecting the eyes are the orbicularis oculi, levator palpebrae superioris, and corrugator (*Fig. 20.5*). Contraction of these three muscles manifests a variety of emotions such as anger, confusion, and worry. In addition, the orbicularis oculi plays a critical role in maintaining the health of the eye.

ORBICULARIS OCULI

The orbicularis oculi is a complex muscle that is arranged circumferentially around the eye and is attached to the medial and lateral borders of the orbit (*Muscle Attachment Box 20.3*). Its fibers vary in size and length and are primarily type II fibers with rapid contraction velocities [18,27].

Action**MUSCLE ACTION: ORBICULARIS OCULI**

Action	Evidence
Close the eye	Supporting
Pull eyebrows medially	Supporting

The orbicularis oculi is one of the most important muscles of facial expression [17]. By closing the eye in spontaneous blinks, the orbicularis oculi lubricates the eye, spreading the

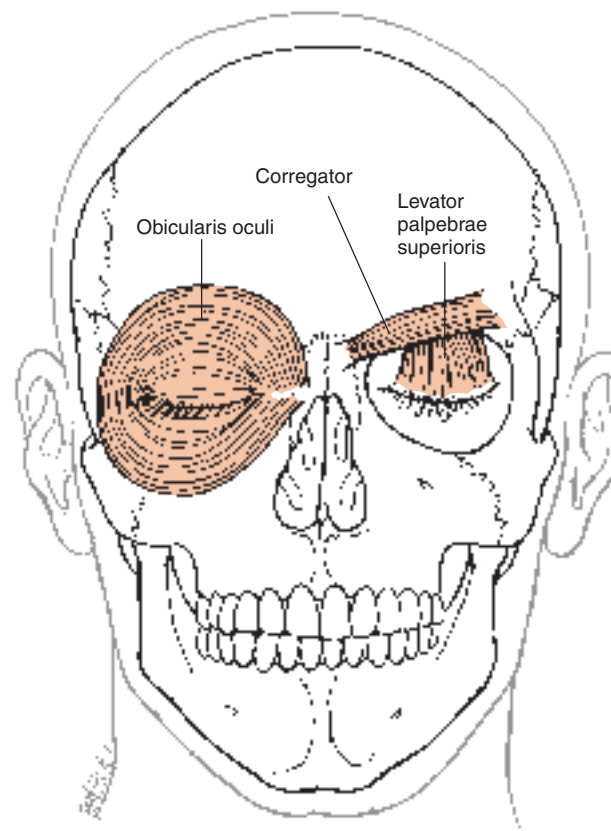


Figure 20.5: The muscles of the face affecting the eye include the orbicularis oculi, the levator palpebrae superioris, and the corrugator.

**MUSCLE ATTACHMENT BOX 20.3****ATTACHMENTS AND INNERVATION OF THE ORBICULARIS OCULI****Bony attachment:**

Orbital part: Nasal part of frontal bone, frontal process of maxilla, medial palpebral ligament

Palpebral part: Medial palpebral ligament and adjacent bone above and below

Lacrimal part: Crest of the lacrimal bone and fascia

Soft tissue attachment:

Orbital part: Palpebral ligament after arching around the upper and lower eyelid

Palpebral part: Palpebral raphe formed by the interlacing of the fibers at the lateral angle of the eye

Lacrimal part: Medial portion of the upper and lower eyelids with the lateral palpebral raphe

Innervation: Temporal and zygomatic branches of facial nerve (7th cranial nerve)



Figure 20.6: Weakness of the orbicularis oculi prevents eye closure and can cause the patient to look surprised because the eye is opened wide.

tears excreted by the lacrimal gland. **Spontaneous blinks** occur at a rate of approximately 12 or 13 blinks per minute (up to 750 blinks per hour) [18,25]. **Reflex blinks** are critical to protecting the eye from foreign objects. The muscle's high density of type II muscle fibers is consistent with the need to perform rapid, fleeting contractions. In contrast, the orbicularis oculi, like other muscles of facial expression, is unable to tolerate sustained contractions of several seconds duration without fatigue [6,18].

The medial and superior muscle fibers of the orbicularis oculi assist in drawing the eyebrows medially, and the muscle is active during the expression of emotions such as anger and contentment [20,50,51]. The wrinkles formed by the contraction of the orbicularis oculi lie perpendicular to the muscle's fibers and radiate from the corners of the eye in the characteristic “crow's feet” pattern [51].

Weakness

Weakness of the orbicularis oculi results in the inability to close the eye (Fig. 20.6). A patient with weakness of the orbicularis oculi often exhibits a perpetual look of surprise because the affected eye is maintained in a wide-open position.

Clinical Relevance

WEAKNESS OF THE ORBICULARIS OCULI: Weakness of the orbicularis oculi is the most serious consequence of facial weakness because it impairs the lubricating mechanism of the eye. If the eye is unable to close at regular and frequent intervals to spread tears over the surface of the eye, the cornea dries, which can lead to ulceration and impaired vision [17]. In addition, foreign objects may enter the eye without the protection of the reflex blink. Consequently, the patient with facial weakness must obtain immediate consultation with an ophthalmology specialist who can prescribe the appropriate intervention to maintain the necessary lubrication and protection of the eye. The patient may wear a protective eye patch to prevent drying of or trauma to the eye.



MUSCLE ATTACHMENT BOX 20.4

ATTACHMENTS AND INNERVATION OF THE LEVATOR PALPEBRAE SUPERIORIS

Bony attachment: Roof of the orbit just in front of the optic canal

Soft tissue attachment: Skin of the upper lid and triangular aponeurosis, which attaches to the mid-point of the medial and lateral orbital margins

Innervation:

Somatic portion: Superior division of the oculomotor nerve (3rd cranial nerve)

Visceral portion: Sympathetic nervous system

LEVATOR PALPEBRAE SUPERIORIS

The levator palpebrae superioris is technically an **extrinsic muscle of the eye** and, unlike the muscles of facial expression, is innervated by the third cranial nerve, the oculomotor nerve (*Muscle Attachment Box 20.4*). It is discussed here because the levator palpebrae superioris is the antagonist to the orbicularis oculi.

Action

MUSCLE ACTION: LEVATOR PALPEBRAE SUPERIORIS

Action	Evidence
Opens the eye	Supporting

It is because the levator palpebrae is not innervated by the facial nerve that a patient with a facial nerve palsy affecting the orbicularis oculi maintains a wide-eyed expression. In the patient with facial weakness, the levator palpebrae pulls without the normal balance of its antagonist, the orbicularis oculi, and the eye remains wide open. In a healthy awake individual, the levator palpebrae superioris maintains a low level of activity to keep the eye open, but activity decreases as the orbicularis oculi closes the eye. Increased activity occurs when the eye opens wide in a look of surprise or excitement [51].

Weakness

Weakness of the levator palpebrae superioris leads to drooping of the upper eyelid, known as **ptosis**. Ptosis interferes with vision, since the eyelid droops over the eye, obscuring the view. Surgical intervention can be useful in mechanically lifting the eyelid to improve vision.

CORRUGATOR

The corrugator lies deep to the frontalis (*Muscle Attachment Box 20.5*). Unlike the orbicularis oculi, it is composed of approximately equal proportions of type I and type II muscle fibers and, consequently, is more fatigue resistant [18].

**MUSCLE ATTACHMENT BOX 20.5****ATTACHMENTS AND INNERVATION OF THE CORRUGATOR SUPERCILII**

Bony attachment: Medial bone of the supraciliary arch

Soft tissue attachment: Skin of the medial half of the eyebrow, above the middle of the supraorbital margin, blending with the orbicularis oculi

Innervation: Temporal branch of facial nerve (7th cranial nerve)

Action**MUSCLE ACTION: 6 CORRUGATOR**

Action	Evidence
Pull eyebrows medially and down	Supporting

The corrugator contracts with the orbicularis oculi to pull the eyebrows down (*Fig. 20.7*). It is active when an individual squints to protect the eyes from bright lights. Its activity also is a characteristic part of a frown and is associated with emotions such as anger and confusion [15,20,50,51]. Contraction of the corrugator produces vertical creases at the superior aspect of the nose.

Weakness

There is no known functional deficit associated with weakness of the corrugator muscle, but weakness leads to flattening of the skin at the medial aspect of the eyebrow.



Figure 20.7: Contraction of the corrugator with the medial portion of the orbicularis oculi draws the eyebrows together.

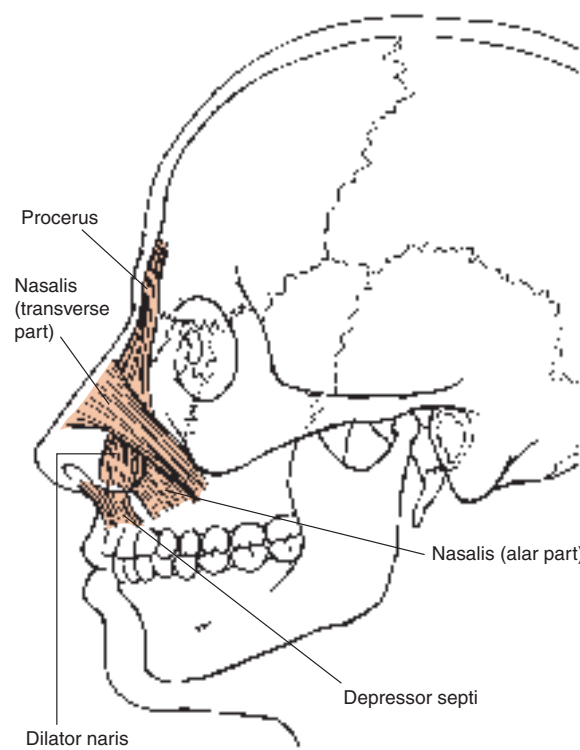


Figure 20.8: Muscles of the nose include the procerus, the transverse and alar portions of the nasalis, the dilator naris, and the depressor septi.

Muscles of the Nose

There are four primary facial muscles of the nose: the procerus, the nasalis with its transverse and alar portions, the dilator naris, and the depressor septi [9,10,12] (*Fig. 20.8*). The procerus appears to function primarily in facial expressions [9,10]. The other muscles of this group also move or stabilize the nose and are active during respiration [9,10,12]. The functional importance of these muscles is not well studied and, consequently, the functional significance of weakness in these muscles is unknown, although weakness does contribute to facial asymmetry. Only the actions of these muscles are discussed below.

PROCERUS

The procerus lies close to the orbicularis oculi and the corrugator (*Muscle Attachment Box 20.6*).

**MUSCLE ATTACHMENT BOX 20.6****ATTACHMENTS AND INNERVATION OF THE PROCERUS**

Bony attachment: Fascia covering the lower parts of the nasal bone and upper part of the lateral nasal cartilage

Soft tissue attachment: Skin over the lower part of the forehead and between the eyebrows

Innervation: Superior buccal branches of facial nerve (7th cranial nerve)



Figure 20.9: Contraction of the procerus produces wrinkles across the bridge of the nose. Contraction often occurs with contraction of the levator labii superioris and the levator anguli oris in a look of distaste.

Action

MUSCLE ACTION: PROCERUS

Action	Evidence
Pull the nose cranially	Supporting
Pull eyebrows down	Supporting

Contraction of the procerus contributes to the characteristic look of distaste, as an individual wrinkles the nose at an unpleasant smell, flavor, or idea [2,51] (*Fig. 20.9*). The muscle participates with the orbicularis oculi and corrugator in a frown [50,51].

NASALIS

The nasalis consists of two components, the transverse and alar segments [9,10,12,39] (*Muscle Attachment Box 20.7*).

Actions

MUSCLE ACTION: NASALIS, TRANSVERSE SEGMENT

Action	Evidence
Compress and stabilize lateral wall of nose	Supporting

EMG data support the role of the transverse portion of the nasalis muscle in compressing or flattening the nose [12]. Such movement is associated with a look of haughtiness. The



MUSCLE ATTACHMENT BOX 20.7

ATTACHMENTS AND INNERVATION OF THE NASALIS

Bony attachment:

Transverse part: Upper end of the canine eminence and lateral to the nasal notch of the maxilla

Alar part: Maxilla above the lateral incisor tooth

Soft tissue attachment:

Transverse part: Aponeurosis of the nasal cartilages

Alar part: Cartilaginous ala of the nose and skin of the lateral part of the lower margin of the ala of the nose

Innervation: Superior buccal branches of facial nerve (7th cranial nerve)

movement also is important functionally in closing off the nasal airway during speech when making vocal sounds such as “b” and “p.”

Studies report activity in the transverse portion of the nasalis during inspiration [9,10]. These studies suggest that this activity stiffens the outer walls of the nose to prevent collapse as the pressure within the nose decreases during inspiration. Additional studies are needed to verify or refute this explanation.

MUSCLE ACTION: NASALIS, ALAR SEGMENT

Action	Evidence
Dilate nostrils	Supporting
Draw nostrils down and posteriorly	Inadequate

Flaring the nostrils elicits EMG activity in the alar portion of the nasalis [12]. Although the ability to flare the nostrils seems unimportant to most humans, studies demonstrate activity in this muscle during inspiration, particularly during increased respiration following exercise [9,10,12,49]. The activity of the alar portion of the nasalis appears to stabilize the nostrils during inspiration while the pressure within the nose is low, tending to collapse the nostrils.

DILATOR NARIS

The dilator naris is described by some as a part of the nasalis [51] but is described separately in this text because recent studies analyze and describe it separately [9,10,12] (*Muscle Attachment Box 20.8*).



MUSCLE ATTACHMENT BOX 20.8

ATTACHMENTS AND INNERVATION OF THE DILATOR NARIS

Soft tissue attachment: The cartilaginous ala of the nose

Innervation: Superior buccal branches of facial nerve (7th cranial nerve)

Actions

MUSCLE ACTION: DILATOR NARIS

Action	Evidence
Dilate nostrils	Supporting

The dilator naris appears to function with the alar portion of the nasalis to maintain the shape of the nose during inspiration [9,10,12].

DEPRESSOR SEPTI

The depressor septi is a small muscle lying at the base of the nose (*Muscle Attachment Box 20.9*).

Action

MUSCLE ACTION: DEPRESSOR SEPTI

Action	Evidence
Pull nose down	Supporting
Elevate upper lip	Inadequate

EMG activity is reported in the depressor septi when subjects attempt to flatten the nose or to “look down the nose” in a snobbish manner [9,12]. The muscle also is active during inspiration with the other muscles of the nose, presumably to stabilize the nose.



MUSCLE ATTACHMENT BOX 20.9

ATTACHMENTS AND INNERVATION OF THE DEPRESSOR SEPTI

Bony attachment: Incisive fossa of the maxilla

Soft tissue attachments: Mobile part of the nasal septum and posterior part of the ala of the nose

Innervation: Superior buccal branches of facial nerve (7th cranial nerve)

Muscles of the Mouth

The muscles of the mouth serve several purposes:

- Control the aperture of the mouth
- Stabilize the oral chamber and alter its volume
- Change the position of the mouth and surrounding skin to produce varied verbal sounds and convey a wide spectrum of emotions from elation to abject sorrow

The muscles that attach to the lips and act as **constrictors of the mouth** consist of the orbicularis oris and the mentalis (*Fig. 20.10*). The **dilators of the mouth** are the zygomaticus, risorius, levator labii superioris, levator labii superioris alaeque nasi, levator anguli oris, depressor labii inferioris, depressor anguli oris, and platysma (*Fig. 20.11*). Control of the oral aperture maintains food and liquid within the oral cavity. The size and shape of the mouth also are critical in speech, contributing to the variety of vowel and consonant sounds in oral speech [2,29]. The **volume regulators** are the buccinator muscles.

Although each muscle applies a unique pull on the lips or cheeks, studies consistently demonstrate that muscles of the mouth participate together during eating and speech [2,4,11,29,53]. It is virtually impossible to activate these muscles

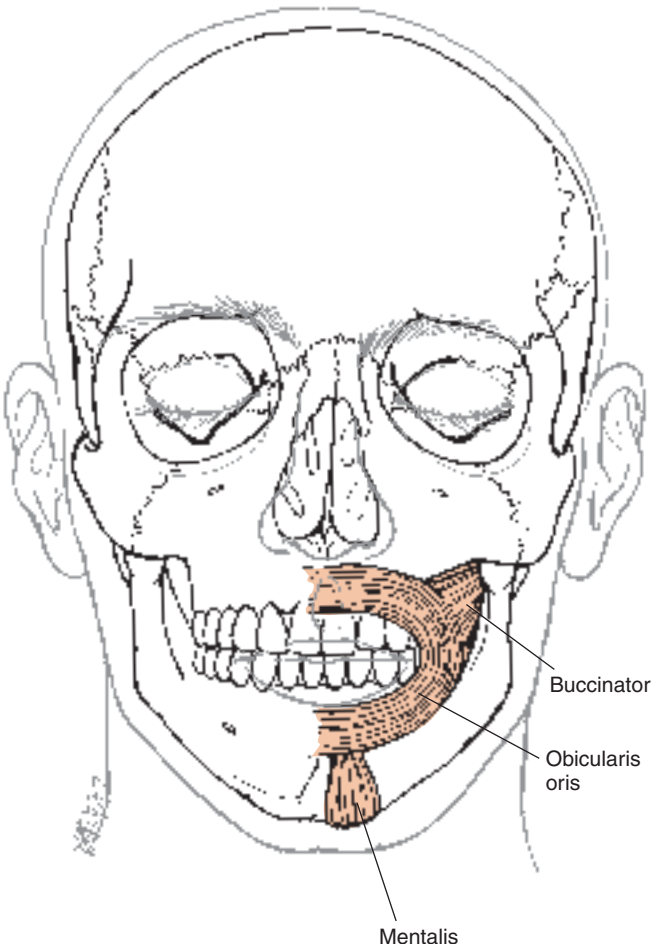


Figure 20.10: Constrictor muscles of the mouth are the orbicularis oris and the mentalis muscles. The buccinator controls the volume of the mouth.

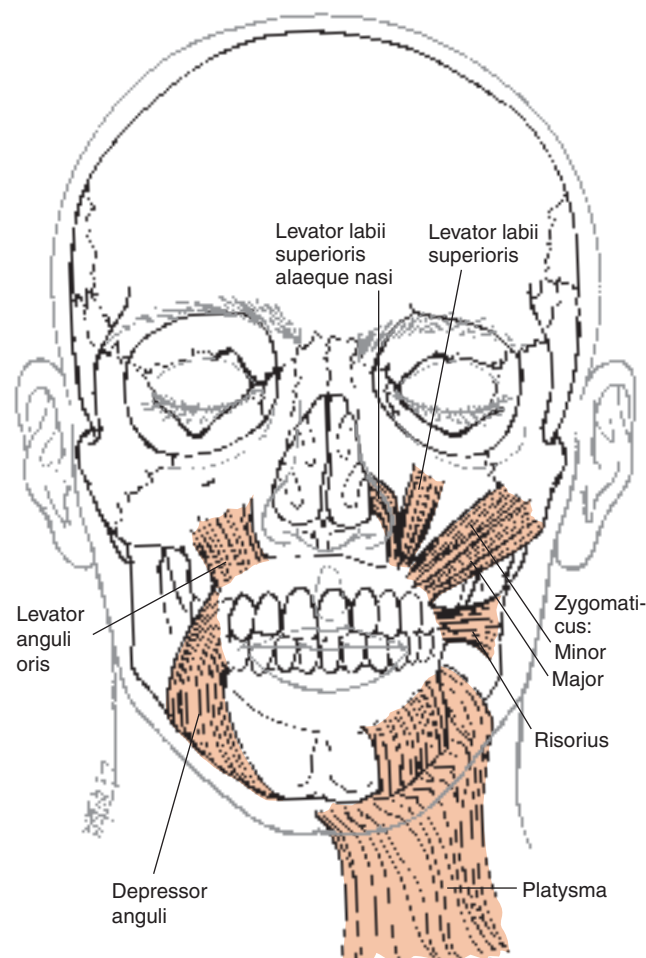


Figure 20.11: Dilator muscles of the mouth are the zygomaticus, risorius, levator labii superioris and levator labii superioris alaeque nasi, levator anguli oris, depressor labii inferioris, depressor anguli oris, and platysma.

individually through voluntary contraction and almost as difficult to isolate them with electrical stimulation [4]. Consequently, evaluation requires the assessment of the coordinated movements of the mouth in activities such as smiling, eating, and speaking. Weakness is most apparent in the asymmetrical and sometimes grotesque facial movements that result from a loss of balance among these muscles. With weakness of the muscles of the mouth on one side of the face, the unaffected muscles pull the mouth toward the intact side, since there is no counteracting force from the opposite side. It is important for the clinician to recognize that this imbalance produces a mouth that looks smooth and “normal” on the weakened side but contracted and contorted on the unaffected side. Care is needed to correctly distinguish the weak from the unaffected side.

Clinical Relevance

BELL'S PALSY: Acute idiopathic facial nerve palsy is known as **Bell's palsy** and is characterized by weakness of the muscles innervated by the facial nerve (7th cranial nerve)



Figure 20.12: A facial nerve palsy on the left produces weakness of the muscles innervated by the facial nerve on the left. This individual displays classic signs of facial weakness, including absence of forehead wrinkles on the left. The left eye is abnormally wide open, and the mouth is pulled to the strong side.

(Fig. 20.12). It typically is unilateral and usually temporary, although the time course of recovery varies from days to years [8,37]. Exercise and biofeedback have been shown to enhance recovery in patients with facial nerve palsies [7,8]. Clinicians must be able to evaluate the integrity of the muscles of facial expression to establish goals, implement treatment, and monitor progress. It is essential that clinicians be able to identify weakness even when unable to apply a specific muscle assessment to each individual muscle.

ORBICULARIS ORIS

The orbicularis oris is one of the most important muscles of facial expression because it is the primary constrictor muscle of the mouth (*Muscle Attachment Box 20.10*). Although it usually is described as a single muscle [39], its superior and inferior portions found in the upper and lower lips, respectively, can function independently [2,43,51,54].



MUSCLE ATTACHMENT BOX 20.10

ATTACHMENTS AND INNERVATION OF THE ORBICULARIS ORIS

Soft tissue attachments: To the fibrous intersection of many muscles, known as the *modulus*, located lateral to the corners of the mouth and into the soft tissue of the lips. It is a sphincter muscle formed by various muscles converging on the mouth.

Innervation: Lower buccal and mandibular branches of facial nerve (7th cranial nerve)

Actions

MUSCLE ACTION: ORBICULARIS ORIS

Action	Evidence
Close lips	Supporting

The orbicularis oris is the **sphincter** for the mouth and is active whenever mouth closure is needed. It is active in chewing, to retain the food within the mouth [45,46,53]. It is used to help slide food from a utensil such as a fork or spoon, and it is essential during sucking through a straw or blowing on a clarinet [33,35,39,51]. It participates in speech to make sounds such as “p” and “b” and assists in the expression of love or friendship, since it is the muscle used to kiss [41,53].

The orbicularis oris has a relatively large cross-sectional area and, consequently, is capable of forceful contractions. Studies report compression forces between the two lips up to 2–4 N (approximately 0.5–1.0 lb) [16,45].

Weakness

Weakness of the orbicularis oris diminishes the ability to close the mouth firmly, producing **oral incontinence**. A patient with weakness of the orbicularis oris muscle reports a tendency to drool or an inability to hold liquid in the mouth. Attempts to whistle are futile, with the air leaking out through the weakened side of the mouth. The patient may also exhibit altered speech, with particular difficulty in pronouncing words that include the sounds of letters such as “p,” “b,” and “w.”

A patient with weakness of the orbicularis oris exhibits flattening of the lips on the affected side. When the muscle contracts, the lips are pulled toward the unaffected side, producing a distorted posture of the mouth, particularly pronounced on the sound side (Fig. 20.13).



Figure 20.13: Contraction of the orbicularis oris with unilateral weakness pulls the mouth to the strong side and causes the weak side to appear smooth and without wrinkles.



MUSCLE ATTACHMENT BOX 20.11

ATTACHMENTS AND INNERVATION OF THE MENTALIS

Bony attachment: Incisive fossa of the mandible
Soft tissue attachment: Skin of the chin
Innervation: Mandibular branch of facial nerve (7th cranial nerve)

MENTALIS

Although the mentalis has no direct connection to the lips, it is the only other muscle that can assist the orbicularis oris in closing the mouth (*Muscle Attachment Box 20.11*).

Actions

MUSCLE ACTION: MENTALIS

Action	Evidence
Raise and protrude lower lip	Supporting
Raise and wrinkle skin of chin	Supporting

The mentalis helps the orbicularis oris in sucking actions by pulling the lower lip up and forward, and the muscle is active in such actions as sucking on or blowing through a straw [1,2,43,47,51]. Protrusion of the lower lip also is characteristic of a pouting expression (Fig. 20.14).



Figure 20.14: Contraction of the mentalis pulls the lower lip anteriorly and superiorly, the characteristic position in a pout.



MUSCLE ATTACHMENT BOX 20.12

ATTACHMENTS AND INNERVATION OF THE ZYGOMATICUS

Bony attachment:

Major: Zygomatic portion of zygomatic arch

Minor: Anterior and lateral zygomatic bone

Soft tissue attachment:

Major: Skin and orbicularis oris at the angle of the mouth

Minor: Skin and muscle of the upper lip

Innervation: Buccal branches of facial nerve (7th cranial nerve)

Weakness

Weakness of the mentalis limits the ability to protrude the lower lip. The weakness contributes to the asymmetrical posture of the mouth during sucking actions, with the lower lip on the affected side appearing flat while the lip on the unaffected side appears distorted as it protrudes alone.

ZYGOMATICUS

The zygomaticus is one of the muscles that dilate the orifice of the mouth, although its primary functional significance is to express emotion (*Muscle Attachment Box 20.12*).

Actions

MUSCLE ACTION: ZYGOMATICUS

Action	Evidence
Pull edges of mouth superiorly and laterally	Supporting

The zygomaticus is the **smile muscle**, contributing to the characteristic broad full smile that brings the corners of the mouth toward the eyes [2,32,42] (*Fig. 20.15*). It is important, however, to recognize that several muscles are active in this sort of smile. The zygomaticus does not contract alone [24].

Weakness

Weakness of the zygomaticus alters the form of an attempted smile. As the patient smiles, the unaffected muscle pulls the mouth vigorously toward the sound side, producing a rather grotesque image [24] (*Fig. 20.16*).

Clinical Relevance

PSYCHOLOGICAL CHALLENGES FOR A PATIENT WITH FACIAL PALSY: Weakness of the facial muscles, particularly around the mouth, produces significant social challenges to

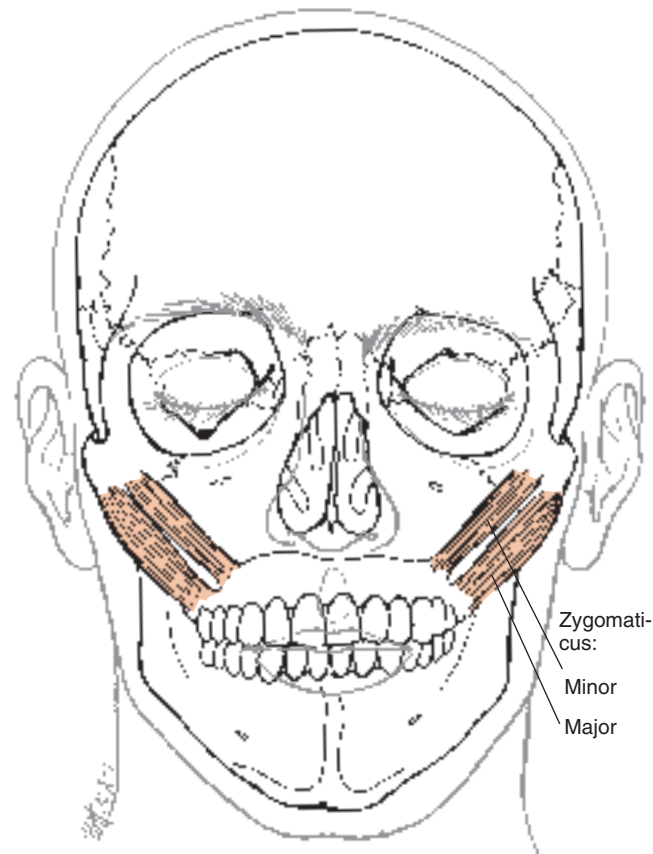


Figure 20.15: The primary muscle of a broad smile is the zygomaticus, but most of the other dilators of the mouth also participate, pulling the lips away from the teeth.

the patient. Weakness of the orbicularis oris may make eating difficult and embarrassing, as the patient is unable to avoid leakage of the food or liquid from the mouth. In addition, facial expressions that are the natural manifestations of emotions such as joy or sorrow are no longer the familiar smiles or frowns but rather grotesque caricatures of such expressions. As a result, many patients are reluctant to leave the privacy of their own homes [48].



Figure 20.16: Contraction of the dilator muscles with unilateral weakness pulls the mouth to the strong side, leaving the weak side smooth and without wrinkles. (Photo courtesy of Martin Kelley MSPT, University of Pennsylvania Health Systems, Philadelphia, PA.)

**MUSCLE ATTACHMENT BOX 20.13****ATTACHMENTS AND INNERVATION OF THE RISORIUS**

Bony attachment: Zygomatic bone

Soft tissue attachment: Fascia of the parotid gland, fascia over the masseter muscle, fascia of the platysma, fascia over the mastoid process, and the skin at the angle of the mouth

Innervation: Buccal branches of facial nerve (7th cranial nerve)

RISORIUS

The risorius is another dilator of the mouth and functions with the zygomaticus (*Muscle Attachment Box 20.13*).

Actions**MUSCLE ACTION: RISORIUS**

Action	Evidence
Pull edges of mouth laterally	Supporting

Although the risorius typically contracts with the zygomaticus, when its activity is primary, the risorius produces a grimace that can convey feelings of disgust, dislike, frustration, or other emotions (*Fig. 20.17*).



Figure 20.17: When the risorius is the primary muscle active at the mouth, the lips are pulled laterally in a grimace.

**MUSCLE ATTACHMENT BOX 20.14****ATTACHMENTS AND INNERVATION OF THE LEVATOR LABII SUPERIORIS AND LEVATOR LABII SUPERIORIS ALAEQUE NASI**

Bony attachment: Maxilla and zygomatic bone superior to the infraorbital foramen

Soft tissue attachment: Orbicularis oris of the upper lip and the cartilaginous ala of the nose

Innervation: Buccal branches of facial nerve (7th cranial nerve)

Weakness

Weakness of the risorius, like the zygomaticus, results in a distorted smile with the mouth pulled toward the unaffected side.

LEVATOR LABII SUPERIORIS AND LEVATOR LABII SUPERIORIS ALAEQUE NASI

The two levator labii superioris muscles lie between the nose and the mouth, contributing to the characteristic furrow between the side of the nose and the corners of the mouth (*Muscle Attachment Box 20.14*).

Actions**MUSCLE ACTION: LEVATOR LABII SUPERIORIS AND LEVATOR LABII SUPERIORIS ALAEQUE NASI**

Action	Evidence
Lift the upper lip and turn it outward	Supporting

The action of the two levator labii superioris muscles produces the common look of disgust or revulsion and typically coincides with contraction of the procerus [10]. These muscles also contribute to retraction of the lips during a large smile [2,42]. The levator labii superioris alaeque nasi also contributes to the dilation of the nostrils with the alar portion of the nasalis and the dilator naris [51].

Weakness

Weakness of the two levator labii superioris muscles contributes to a flattening of the lips in a smile. The patient also may report a tendency to bite the upper lip, particularly while eating. Weakness of these muscles tends to flatten the furrow between nose and mouth. Since this furrow deepens with age normally, weakness of the levator labii superioris muscles tends to make an older individual appear younger.

LEVATOR ANGULI ORIS (ALSO KNOWN AS CANINUS)

The levator anguli oris also contributes to the furrow between the nose and upper lip (*Muscle Attachment Box 20.15*).



MUSCLE ATTACHMENT BOX 20.15

ATTACHMENTS AND INNERVATION OF THE LEVATOR ANGULI ORIS (CANINUS)

- Bony attachment: Canine fossa of the maxilla immediately below infraorbital foramen
- Soft tissue attachment: Fibers intermingle with the skin and orbicularis oris at the lateral angle of mouth
- Innervation: Buccal branches of facial nerve (7th cranial nerve)

Actions

MUSCLE ACTION: LEVATOR ANGULI ORIS

Action	Evidence
Lift lateral aspect of upper lip	Supporting

By lifting the lateral aspect of the lip, the levator anguli oris exposes the canine tooth, which gives the muscle its other name, caninus. Although many individuals are unable to isolate this muscle, its action is associated with a sneering expression (Fig. 20.18). Like the other dilator muscles, the levator anguli oris participates in a broad smile [42].

Weakness

Weakness of the levator anguli oris contributes to a distorted smile.



Figure 20.18: When the levator anguli oris is active primarily, the lip is pulled up and laterally in a sneer.



MUSCLE ATTACHMENT BOX 20.16

ATTACHMENTS AND INNERVATION OF THE DEPRESSOR LABII INFERIORIS

- Bony attachment: Oblique line of the outer surface of the mandible between the symphysis and mental foramen deep to the depressor anguli oris
- Soft tissue attachment: Skin and mucosa of the lower lip, mingling with the orbicularis oris
- Innervation: Mandibular branches of facial nerve (7th cranial nerve)

DEPRESSOR LABII INFERIORIS

Depressor labii inferioris is a dilator of the mouth, affecting the lower lip (*Muscle Attachment Box 20.16*).

Actions

MUSCLE ACTION: DEPRESSOR LABII INFERIORIS

Action	Evidence
Pull lower lip down and turn it outward	Supporting

Contraction of the depressor labii inferioris exposes the lower teeth. The action of the depressor labii inferioris is generally associated with the emotions of sadness or anger manifested by a frown. However, the muscle also appears to be active in large smiles in which the lips are pulled back from both rows of teeth [38,42].

Weakness

Like all of the muscles that attach to the lips described so far, weakness of the depressor labii inferioris contributes to distortions of the mouth when the patient frowns or smiles, and the mouth is pulled toward the stronger side.

DEPRESSOR ANGULI ORIS

The last of the primary depressors of the lips, the depressor anguli oris, is active with the depressor labii inferioris (*Muscle Attachment Box 20.17*).



MUSCLE ATTACHMENT BOX 20.17

ATTACHMENTS AND INNERVATION OF THE DEPRESSOR ANGULI ORIS

- Bony attachment: Mental tubercle and oblique line of mandible
- Soft tissue attachment: Orbicularis oris and skin at angle of mouth
- Innervation: Mandibular branches of facial nerve (7th cranial nerve)

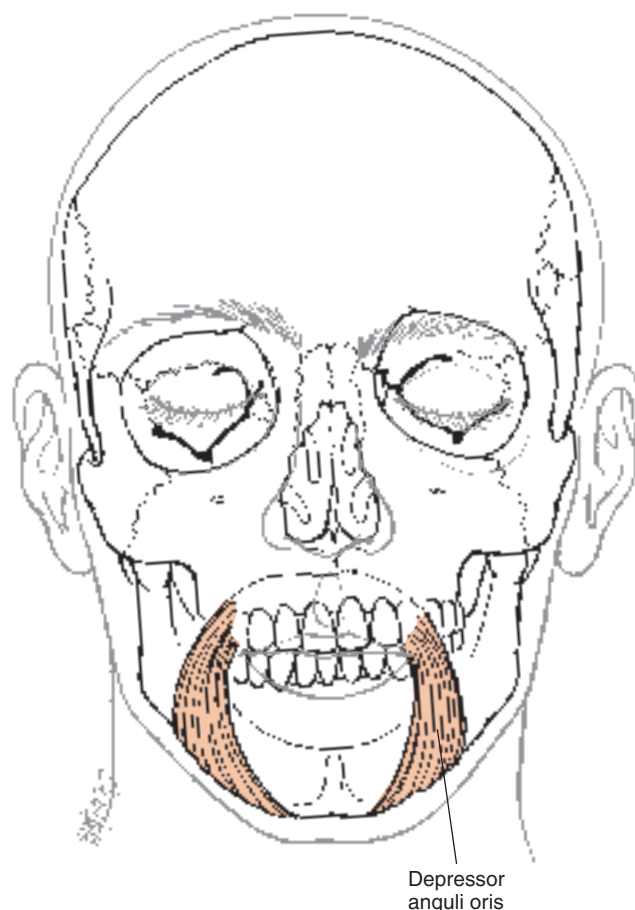


Figure 20.19: The depressor anguli oris is primarily responsible for the classic frown, although the other depressors of the lips are active as well.

Actions

MUSCLE ACTION: DEPRESSOR ANGULI ORIS

Action	Evidence
Pull angles of mouth down and laterally	Supporting

The action of the depressor anguli oris is associated with the emotion of sadness, since contraction contributes to the classic frown (*Fig. 20.19*).

Weakness

Weakness of the depressor anguli oris contributes, with the other muscles of the mouth, to the distortions of the mouth as it is pulled toward the unaffected side. Loss of the depressor anguli oris is particularly apparent when a patient, depressed or saddened by the effects of the facial weakness, begins to cry. The mouth is pulled down and laterally by the unaffected depressor anguli oris, causing the whole mouth to deviate toward the strong side (*Fig. 20.20*).



Figure 20.20: Contraction of the depressors of the lip with unilateral weakness pulls the mouth to the strong side, leaving the weak side smooth and without wrinkles. (Photo courtesy of Martin Kelley, MSPT, University of Pennsylvania Health Systems, Philadelphia, PA.)

PLATYSMA

The platysma is a broad, thin sheet of muscle extending from the mouth to the upper thoracic region (*Muscle Attachment Box 20.18*). It is superficial, lying just below the skin in the cervical region.

Actions

MUSCLE ACTION: PLATYSMA

Action	Evidence
Pull corners of mouth and lower lip down	Supporting
Assist in inspiration	Inadequate
Support skin in cervical region	Inadequate



MUSCLE ATTACHMENT BOX 20.18

ATTACHMENTS AND INNERVATION OF THE PLATYSMA

Bony attachment: Skin and superficial fascia of the upper pectoral and deltoid regions. Fibers cross the clavicle and pass obliquely upward and medially along the sides of the neck.

Soft tissue attachment: Anterior fibers of either side interlace with each other below the chin, at the symphysis menti. Intermediate fibers attach at the lateral half of the lower lip and lower border of the body of the mandible. Posterior fibers connect with depressor labii inferioris and depressor anguli oris and pass the angle of the jaw to insert into the skin and subcutaneous tissue of the lower part of the face.

Innervation: Cervical branch of the facial nerve (7th cranial nerve)



Figure 20.21: Contraction of the platysma contributes to a look of horror.

The actions of the platysma are not well studied. The attachments of the platysma are consistent with the actions listed above [2,51]. Contraction of the platysma often contributes to a look of horror (*Fig. 20.21*). Observation of an individual in respiratory distress typically reveals contraction of the platysma during inspiration, but the significance of such a contraction is unknown.

Weakness

The significance of platysma weakness is unknown.

BUCCINATOR

The buccinator is the muscle of the cheek, with only an indirect attachment to the lips by way of the orbicularis oris (*Muscle Attachment Box 20.19*).



MUSCLE ATTACHMENT BOX 20.19

ATTACHMENTS AND INNERVATION OF THE BUCCINATOR

Bony attachment: Outer surface of alveolar process of maxilla and mandible opposite the sockets of the molar teeth and the anterior border of the pterygo-mandibular raphe posteriorly

Soft tissue attachment: The orbicularis oris and the lips and submucosa of the mouth

Innervation: Lower buccal branches of facial nerve (7th cranial nerve)

Actions

MUSCLE ACTION: BUCCINATOR

Action	Evidence
Compress the cheek	Supporting

The buccinator muscle is an essential muscle in chewing. By compressing the cheeks, the buccinator keeps the bolus of food from getting caught in the **buccal space**, the space between the mandible and the cheek. The buccinator also controls the volume of the oral cavity and thereby controls the pressure within the cavity. This role is particularly important to musicians who play brass or woodwind instruments but is used by anyone who has blown out the candles on a birthday cake. The buccinator stiffens the cheeks so that the air can be expelled under pressure while contraction of the orbicularis oris muscles directs the air stream toward the target [35].

Weakness

Weakness of the buccinator produces several serious difficulties in chewing. Weakness of the muscle allows the food to become sequestered in the buccal space, so the patient cannot grind the food effectively between the teeth. Prolonged sequestering also can lead to skin breakdown and tooth decay. In addition, with little control of the cheek, a patient is prone to biting the inner wall of the cheek while chewing. Weakness of the buccinator also produces difficulty in blowing air out forcefully through pursed lips, so a patient has difficulty playing a brass or wind instrument.

MUSCLES THAT MOVE THE EYES

There are seven **extrinsic muscles of the eye**, including the levator palpebrae superioris, which is discussed earlier in this chapter. The remaining six muscles are responsible for moving the eye within the orbit and include the superior, inferior, medial, and lateral rectus muscles and the superior and inferior oblique muscles (*Fig. 20.22*). Evaluation and treatment of these muscles are the primary responsibility of ophthalmologists and neurologists. Rehabilitation specialists participate in the conservative management of patients with impairments of these muscles and require an understanding of the basic mechanisms that produce normal eye movements described in this text.

To understand the movements produced by these muscles, it is necessary to appreciate the axes of motion that form the reference frame for eye movement (*Fig. 20.23*). Movements of the eye are described with respect to the axes through the eye itself. **Elevation** and **depression** occur about the medial lateral axis; **medial** and **lateral rotation**, also known as **adduction** and **abduction**, occur about a vertical axis; and **intorsion** and **extorsion** occur about the anterior-posterior axis. Intorsion is defined as the motion that rotates the superior surface of the eye medially toward the nose. Extorsion is motion of the same point laterally toward the ear.

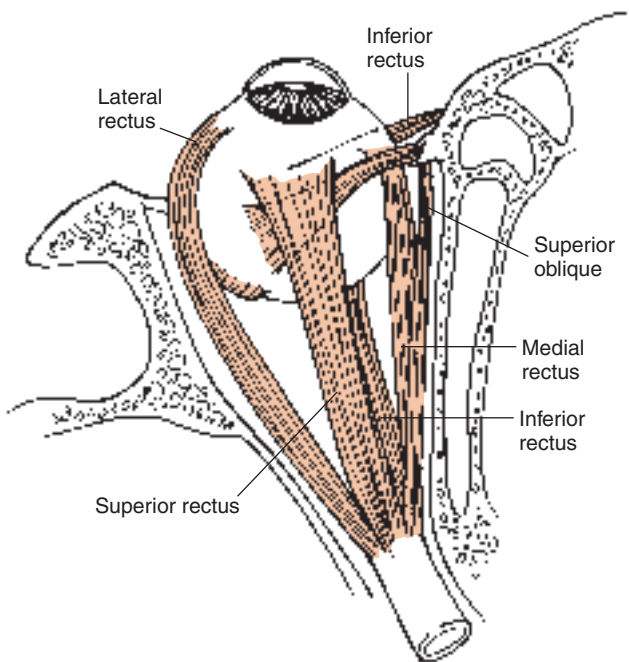


Figure 20.22: The extrinsic muscles that move the eye are the medial and lateral rectus, the superior and inferior rectus, and the superior and inferior oblique muscles.

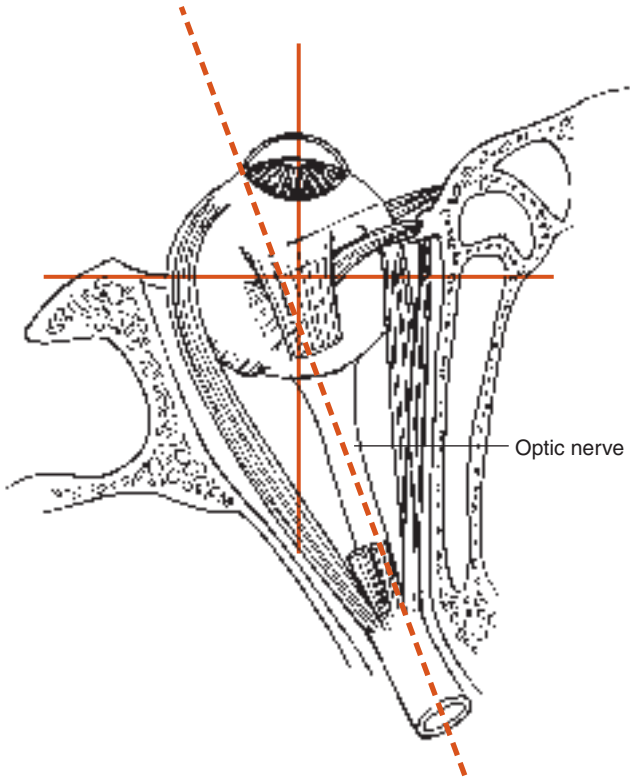


Figure 20.24: Axes of the eye compared with the alignment of the orbit. The axes of the eye are aligned in the cardinal planes of the body; however, the orbits of the eyes project anteriorly and laterally.

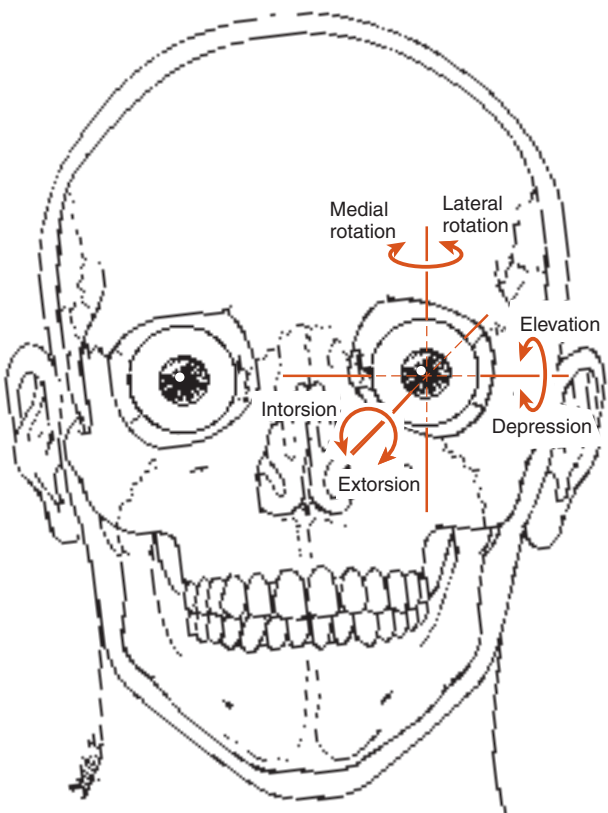


Figure 20.23: Motion about the vertical axis is medial and lateral rotation (adduction and abduction, respectively). Motion about a medial lateral axis is elevation and depression, and motion about an anterior posterior axis is intorsion and extorsion. Intorsion is the movement that moves the superior aspect of the eye medially, and extorsion moves the superior surface of the eye laterally.

The orbit of the eye projects anteriorly and laterally within the skull, but the anterior–posterior axis of each eye lies in the sagittal plane during normal forward vision (*Fig. 20.24*). The differences between the axes of the eye and the axes of the orbit contribute to the complexity of the motions produced by the extrinsic muscles of the eye. Additionally, the extrinsic muscles cannot be observed or assessed by palpation; EMG analysis also is rarely possible. Consequently, these muscles are not well studied. The following provides a basic description of the current understanding of the muscles that move the eye. Effects of weakness are discussed together following the descriptions of all the muscles.

MEDIAL AND LATERAL RECTUS MUSCLES

Both the medial and lateral rectus muscles lie close to the transverse plane when vision is focused on the horizon, so their activity produces movement about a vertical axis through the eye [51] (*Muscle Attachment Box 20.20*).

Actions

MUSCLE ACTION: MEDIAL RECTUS

Action	Evidence
Rotate eye medially (adduct)	Supporting



MUSCLE ATTACHMENT BOX 20.20

**ATTACHMENTS AND INNERVATION
OF THE MEDIAL AND LATERAL RECTUS
MUSCLES**

Bony attachment: The optic canal by a common annular ligament

Soft tissue attachment: The medial and lateral scleral surfaces of the eye respectively, posterior to the cornea

Innervation: Medial rectus by the oculomotor nerve (3rd cranial nerve). Lateral rectus by the abducens nerve (6th cranial nerve).

MUSCLE ACTION: LATERAL RECTUS

Action	Evidence
Rotate eye laterally (abduct)	Supporting

The medial and lateral rectus muscles work together to turn the gaze to the right or left [28,51]. As the head faces anteriorly, gaze to the left requires contraction of the left lateral rectus and the right medial rectus (*Fig. 20.25*).

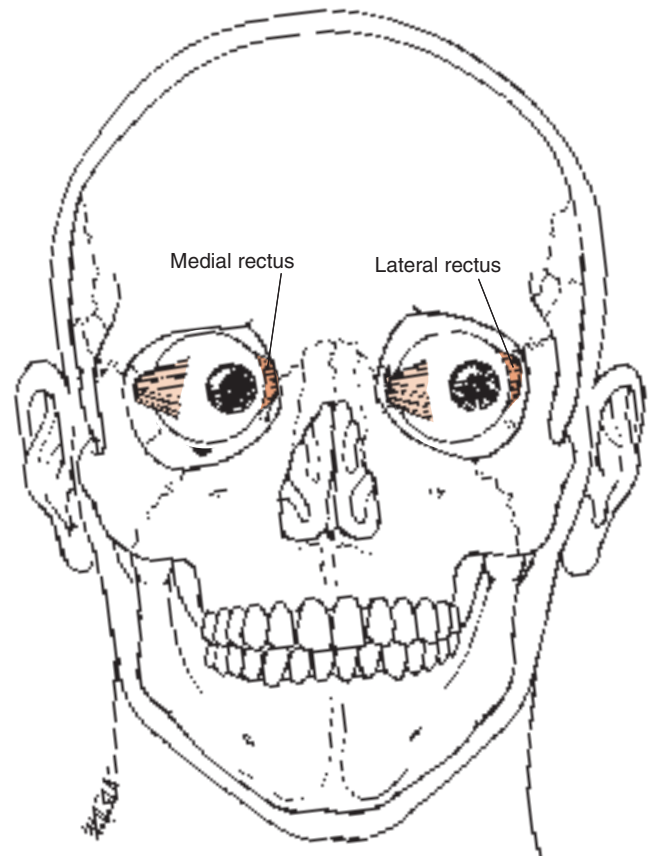


Figure 20.25: Movement of both eyes to the left while the head faces forward requires the medial rectus on the right and the lateral rectus on the left.



MUSCLE ATTACHMENT BOX 20.21

**ATTACHMENTS AND INNERVATION
OF THE SUPERIOR AND INFERIOR
RECTUS MUSCLES**

Bony attachment: Optic canal, by a common annular ligament

Soft tissue attachment: Superior and inferior scleral surfaces of the eye, respectively, posterior to the cornea

Innervation: Oculomotor nerve (3rd cranial nerve)

SUPERIOR AND INFERIOR RECTUS MUSCLES

The actions of the superior and inferior rectus muscles are more complex than those of the medial and lateral recti because the superior and inferior recti are more or less aligned along the walls of the orbit and, therefore, pull obliquely with respect to the axes of the eye (*Muscle Attachment Box 20.21*).

Actions

MUSCLE ACTION: SUPERIOR RECTUS

Action	Evidence
Eye elevation	Supporting
Eye medial rotation	Supporting
Eye intorsion	Supporting

The superior rectus clearly contributes to elevation of the eye, but its contribution to the other motions is less obvious. Careful observation of the attachment of the superior rectus reveals that it lies medial to the anterior-posterior and vertical axes, which explains the muscle's contributions to intorsion and medial rotation respectively [28,51] (*Fig. 20.26*).

Actions

MUSCLE ACTION: INFERIOR RECTUS

Action	Evidence
Eye depression	Supporting
Eye medial rotation	Supporting
Eye extorsion	Supporting

The attachment of the inferior rectus muscle on the inferior surface of the eye explains its role as a depressor of the eye. It passes medial to the vertical axis to participate in medial rotation and attaches lateral to the anterior-posterior axis to contribute to extorsion [28,51] (*Fig. 20.25*).

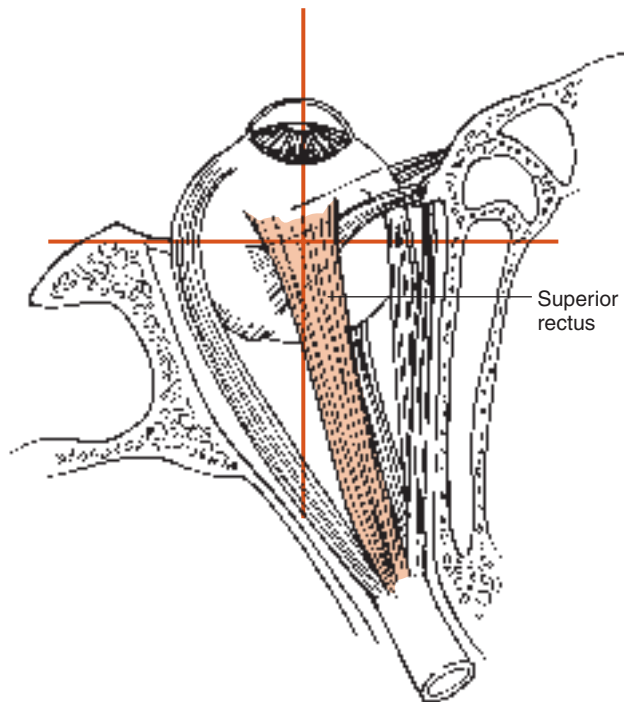


Figure 20.26: The superior rectus is aligned with the orbit of the eye, but its position medial to the vertical and the anterior-posterior axes explains its contributions to medial rotation and intorsion.

SUPERIOR OBLIQUE

The superior oblique muscle travels a circuitous route to the eye, wrapping around a pulley-like structure and traveling posteriorly and laterally to attach posterior to the medial-lateral and vertical axes and lateral to the anterior-posterior axis [28,51,52] (*Muscle Attachment Box 20.22*) (*Fig. 20.22*).



MUSCLE ATTACHMENT BOX 20.22

ATTACHMENTS AND INNERVATION OF THE SUPERIOR OBLIQUE MUSCLE

Bony attachment: Sphenoid bone superior and medial to the optic canal

Soft tissue attachment: Sclera of the eye, posterior to the eye's equator and on the superior lateral surface, between the attachments of the superior rectus and the lateral rectus muscles. As the muscle progresses anteriorly through the orbit toward its attachment on the eye, it passes through a fibrous loop, or pulley, to redirect its fibers posteriorly and laterally.

Innervation: Trochlear nerve (4th cranial nerve)



MUSCLE ATTACHMENT BOX 20.23

ATTACHMENTS AND INNERVATION OF THE INFERIOR OBLIQUE MUSCLE

Bony attachment: the maxilla on the floor of the orbit

Soft tissue attachment: the sclera of the eye, on its inferior, posterior, and lateral surfaces, between the rectus inferior and lateralis muscles

Innervation: Oculomotor nerve (3rd cranial nerve)

Actions

MUSCLE ACTION: SUPERIOR OBLIQUE

Action	Evidence
Eye depression	Inadequate
Eye lateral rotation	Inadequate
Eye intorsion	Inadequate

INFERIOR OBLIQUE

The inferior oblique muscle travels posteriorly and laterally to its attachment posterior and lateral to the axes of the eye [28,51,52] (*Muscle Attachment Box 20.23*).

Actions

MUSCLE ACTION: INFERIOR OBLIQUE

Action	Evidence
Eye elevation	Inadequate
Eye lateral rotation	Inadequate
Eye extorsion	Inadequate

WEAKNESS OF THE MUSCLES THAT MOVE THE EYE

Movements of the eyes appear to be the result of a complex and rhythmic coordination of the muscles of the eye. The eye is moving continuously in individuals with normal motor control of the eyes, and it is likely that all of the muscles of the eyes contract together, producing a steady gaze even when the body or the target moves in space. An imbalance among the extrinsic muscles of the eye produces **strabismus**, the inability to direct the gaze of both eyes toward an object [52]. Strabismus in adults may produce double vision, or **diplopia**, although young children are often able to accommodate by ignoring the input from the misaligned eye. Weakness of either medial or lateral rectus may impair the ability to scan from side to side, creating difficulties in such activities as reading. For example, a lesion of the abducens (sixth cranial nerve) produces weakness of the lateral rectus muscle. The antagonistic medial rectus pulls the eye into medial rotation,

producing a “crossed eye.” Peripheral vision also is challenged if the lateral rectus is impaired, although compensations by head movements may be available.

Clinical Relevance

RESTORING MUSCLE BALANCE SURGICALLY: *Imbalance in muscle strength of the extrinsic muscles of the eye may produce significant vision disturbances, including double vision, or diplopia. Muscle balance can sometimes be restored by increasing the strength of the weaker muscle through exercise. But sometimes the intervention aims to decrease the effect of the stronger muscle. This can be accomplished surgically by changing the moment that the stronger muscle can generate. Haslwanter and colleagues suggest a procedure to relocate the attachment of the stronger muscle closer to the axis of rotation, thereby reducing the moment generated during muscle contraction [19,21]. The reader may be surprised to recognize that the basic principles of biomechanics learned in Chapter 1 are relevant even in ophthalmic surgery!*

Weakness of the superior oblique deserves special note, since it alone is innervated by the trochlear nerve (fourth cranial nerve). Although both the inferior rectus and superior oblique muscles depress the eye, only the superior oblique can depress the eye when the eye is medially rotated. An individual with weakness of the superior oblique muscle has difficulty looking down and in, a requirement of many activities of daily living such as descending stairs or examining the keyboard of a computer [52].

Clinical Relevance

TROCHLEAR NERVE INJURY: *A patient may be seen for complaints of frequent tripping when descending stairs. Such complaints commonly result from weakness in the lower extremities. However, visual disturbances specifically associated with weakness of the superior oblique muscle of the eye also may produce complaints of difficulty descending stairs. Trochlear nerve lesions may need to be considered in the absence of direct associations between impairments in the lower extremities and the functional complaints.*

SUMMARY

This chapter presents the function of the muscles of facial expression and the muscles that move the eye. The muscles of facial expression are organized around the orifices of the head, ears, eyes, nose, and mouth. The muscles surrounding the eyes and mouth play a vital role in opening and closing their respective orifices. The muscles of utmost importance are the orbicularis oculi, which closes the eye, protecting

it from foreign matter and helping to lubricate it, and the orbicularis oris, which closes the mouth, essential for normal chewing and speech. The muscles surrounding the nose help control the size of the nasal opening and passageways during respiration and speech.

Weakness in the muscles of facial expression poses a significant threat to the eye and produces impairments in chewing and speech. In addition, weakness of the muscles of facial expression alters the normal facial responses and often results in asymmetrical and grotesque facial postures. In many cases the facial skin is pulled toward the strong muscles, producing smooth unwrinkled skin on the weakened side and excessively wrinkled and puckered skin on the strong side.

The extrinsic muscles of the eye work in concert to produce smooth, well-coordinated eye movements, allowing an individual to maintain a steady gaze even as the individual or target moves. Weakness in any of these muscles impairs the coordinated movements of both eyes and may lead to double vision or reduced vision in a specific field.

The muscles of the face and eyes work together in complex combinations to produce finely controlled facial expressions and discrete eye movements. Impairments of single muscles are uncommon, and isolated examination of individual muscles is unrealistic. Therefore, the clinician needs to appreciate the types of disturbances in movement patterns that can occur with weakness of these muscles.

References

1. Ahlgren J: EMG studies of lip and cheek activity in sucking habits. *Swed Dent J* 1995; 19: 95–101.
2. Basmajian JV, DeLuca CJ: *Muscles Alive. Their Function Revealed by Electromyography*. Baltimore: Williams & Wilkins, 1985.
3. Berzin F: Occipitofrontalis muscle: functional analysis revealed by electromyography. *Electromyogr Clin Neurophysiol* 1989; 29: 355–358.
4. Blair C, Smith A: EMG recording in human lip muscles: can single muscles be isolated? *J Speech Hear Res* 1986; 29: 256–266.
5. Blaustein BH, Gurwood A: Differential diagnosis in facial nerve palsy: a clinical review. *J Am Optom Assoc* 1997; 68: 715–724.
6. Brach JS, VanSwearingen JM: Measuring fatigue related to facial muscle function. *Arch Phys Med Rehabil* 1995; 76: 905–908.
7. Brach JS, VanSwearingen JM: Physical therapy for facial paralysis: a tailored treatment approach. *Phys Ther* 1999; 79: 397–404.
8. Brach JS, VanSwearingen JM, Lenert J, Johnson PC: Facial neuromuscular retraining for oral synkinesis. *Plast Reconstr Surg* 1997; 99: 1922–1931.
9. Brintjes TD, van Olphen AF, Hillen B, Huizing EH: A functional anatomic study of the relationship of the nasal cartilages and muscles to the nasal valve area. *Laryngoscope* 1998; 108: 1025–1032.
10. Brintjes TD, van Olphen AF, Hillen B, Weijs WA: Electromyography of the human nasal muscles. *Eur Arch Otorhinolaryngol* 1996; 253: 464–469.
11. Cacou C, Greenfield BE, McGrouther DA: Patterns of coordinated lower facial muscle function and their importance in facial reanimation. *Br J Plastic Surg* 1996; 49: 274–280.

12. Clark MP, Hunt N, Hall-Craggs M, McGrouther DA: Function of the nasal muscles in normal subjects assessed by dynamic MRI and EMG: its relevance to rhinoplasty surgery. *Plast Reconstr Surg* 1998; 101: 1945–1955.
13. Code C: Asymmetries in ear movements and eyebrow raising in men and women and right- and left-handers. *Percept Mot Skills* 1995; 80: 1147–1154.
14. Dimberg U, Thunberg M: Rapid facial reactions to emotional facial expressions. *Scand J Psychol* 1998; 39: 39–45.
15. Ellis DA: Anatomy of the motor innervation of the corrugator supercilii muscle: clinical significance and development of a new surgical technique for frowning. *J Otolaryngol* 1998; Aug. 27: 222–227.
16. Gentil M, Tournier CL: Differences in fine control of forces generated by the tongue, lips and fingers in humans. *Arch Oral Biol* 1998; 43: 517–523.
17. Gittins J, Martin K, Sheldrick J, et al.: Electrical stimulation as a therapeutic option to improve eyelid function in chronic facial nerve disorders. *Invest Ophthalmol Vis Sci* 1999; 40: 547–554.
18. Goodmurphy CW, Ovalle WK: Morphological study of two human facial muscles: orbicularis oculi and corrugator supercilii. *Clin Anat* 1999; 12: 1–11.
19. Haslwanter T, Hoerantner R, Priglinger S: Reduction of ocular muscle power by splitting of the rectus muscle I: biomechanics. *Br J Ophthalmol* 2004; 88: 1403–1408.
20. Hietanen JK, Surakka V, Linnankoski I: Facial electromyographic responses to vocal affect expressions. *Psychophysiology* 1998; 35: 530–536.
21. Hoerantner R, Priglinger S, Haslwanter T: Reduction of ocular muscle torque by splitting of the rectus muscle II: technique and results. *Br J Ophthalmol* 2004; 88: 1409–1413.
22. Hu S, Wan H: Imagined events with specific emotional valence produce specific patterns of facial EMG activity. *Percept Mot Skills* 2003; 97: 1091–1099.
23. Jancke L: Facial EMG in an anger-provoking situation: individual differences in directing anger outwards or inwards. *Int J Psychophysiol* 1996; 23: 207–214.
24. Johnson PJ, Bajaj-Luthra A, Llull R, Johnson PC: Quantitative facial motion analysis after functional free muscle reanimation procedures. *Plast Reconstr Surg* 1997; 100: 1710–1719.
25. Kaneko K, Sakamoto K: Evaluation of three types of blinks with the use of electrooculogram and electromyogram. *Percept Mot Skills* 1999; 88: 1037–1052.
26. Kendall FP, McCreary EK, Provance PG: *Muscle Testing and Function*. Baltimore: Williams & Wilkins, 1993.
27. Lander T, Wirtschafter JD, Kirschen McLoon L: Orbicularis oculi muscle fibers are relatively short and heterogeneous in length. *Invest Ophthalmol Vis Sci* 1996; 37: 1732–1739.
28. Last RJ: *Eugene Wolff's Anatomy of the Eye and Orbit*. Philadelphia: WB Saunders, 1961.
29. Leanderson R, Persson A, Ohman S: Electromyographic studies of facial muscle activity in speech. *Acta Otolaryngol* 1971; 361–369.
30. Linstrom CJ: Objective facial motion analysis in patients with facial nerve dysfunction. *Laryngoscope* 2002; 112: 1129–1147.
31. Liscic RM, Zidar J: Functional organisation of the facial motor system in man. *Coll Antropol* 1998; 22: 545–550.
32. Messenger DS, Dickson KL, Fogel A: What's in a smile? *Dev Psychol* 1999; 35: 701–708.
33. Murray KA, Larson CR, Logemann JA: Electromyographic response of the labial muscles during normal liquid swallows using a spoon, a straw, and a cup. *Dysphagia* 1998; 13: 160–166.
34. Neely JG, Pomerantz RG: Measurement of facial muscle strength in normal subjects. *Laryngoscope* 2002; 112: 1562–1568.
35. Papsin BC, Maaske LA, McGrail S: Orbicularis oris muscle injury in brass players. *Laryngoscope* 1996; 106: 757–760.
36. Pennock JD, Johnson PC, Manders EK, VanSwearingen JM: Relationship between muscle activity of the frontalis and the associated brow displacement. *Plast Reconstr Surg* 1999; 104: 1789–1797.
37. Qiu WW, Yin SS, Stucker FJ, et al.: Time course of Bell palsy. *Arch Otolaryngol Head Neck Surg* 1996; 122: 967–972.
38. Roedel R, Christen HJ, Laskawi R: Aplasia of the depressor anguli oris muscle: a rare cause of congenital lower lip palsy? *Neuropediatrics* 1998; 29: 215–219.
39. Romanes GJE: *Cunningham's Textbook of Anatomy*. Oxford: Oxford University Press, 1981.
40. Root AA, Stephens JA: Organization of the central control of muscles of facial expression in man. *J Physiol* 2003; 549: 289–298.
41. Ruark JL, Moore CA: Coordination of lip muscle activity by 2-year-old children during speech and nonspeech tasks. *J Speech Lang Hear Res* 1997; 40: 1373–1385.
42. Rubin LR: The anatomy of the nasolabial fold: the keystone of the smiling mechanism. *Plast Reconstr Surg* 1999; 103: 687–691.
43. Schievano D, Rontani RM, Berzin F: Influence of myofunctional therapy on the perioral muscles. Clinical and electromyographic evaluations. *J Oral Rehabil* 1999; 26: 564–569.
44. Schmidt KL, VanSwearingen JM, Levenstein RM: Speed, amplitude, and asymmetry of lip movement in voluntary puckering and blowing expressions: implications for facial assessment. *Motor Control* 2005; 9: 270–280.
45. Stranc MF, Fogel ML: Lip function: a study of oral continence. *Br J Plast Surg* 1984; 37: 550–557.
46. Takada K, Yashiro K, Sorihashi Y, et al.: Tongue, jaw, and lip muscle activity and jaw movement during experimental chewing efforts in man. *J Dent Res* 1996; 75: 1598–1606.
47. Tosello DO, Vitti M, Berzin F: EMG activity of the orbicularis oris and mentalis muscles in children with malocclusion, incompetent lips and atypical swallowing—pt II. *J Oral Rehabil* 1999; 26: 644–649.
48. VanSwearingen JM, Brach JS: Validation of a treatment-based classification system for individuals with facial neuromotor disorders. *Phys Ther* 1998; 78: 678–689.
49. Wheatley JR, Brancatisano A, Engel LA: Respiratory-related activity of cricothyroid muscle in awake normal humans. *J Appl Physiol* 1991; 70: 2226–2232.
50. Wieder JM, Moy RL: Understanding botulinum toxin. Surgical anatomy of the frown, forehead, and periocular region. *Dermatol Surg* 1998; 24: 1172–1174.
51. Williams P, Bannister L, Berry M, et al.: *Gray's Anatomy, The Anatomical Basis of Medicine and Surgery*, Br. ed. London: Churchill Livingstone, 1995.
52. Wilson-Pauwels L, Akesson EJ, Stewart PA: *Cranial Nerves: Anatomy and Clinical Comments*. BC Decker, 1988.
53. Wohlert AB: Perioral muscle activity in young and older adults during speech and nonspeech tasks. *J Speech Hear Res* 1996; 39: 761–770.
54. Wohlert AB, Goffman L: Human perioral muscle activation patterns. *J Speech Hear Res* 1994; 37: 1032–1040.
55. Wolf K, Mass R, Kiefer F, et al.: Characterization of the facial expression of emotions in schizophrenia patients: preliminary findings with a new electromyography method. *Can J Psychiatry* 2006; 51: 335–341.