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Preface

This textbook on eyelid reconstruction represents the culmination of 20 years of contemplation on my part. During my ophthalmic plastic surgery fellowship training from 1999 to 2001, I had hoped for a reference textbook that would distill the options for periorbital reconstruction after skin cancer removal. There were many excellent resources available regarding reconstruction after periocular trauma, but no textbooks dealing exclusively with periorbital tumor excision and post-Mohs micrographic surgery reconstruction, hence my learning was primarily from other sources. Many articles existed in the scientific literature on varying flaps and techniques, but these were not organized with one comprehensive thought process and direct comparisons. I am eternally grateful to my fellowship preceptors, Drs. John Woog, Arthur Grove, Katrinka Heher, and Michael Migliori. They were my primary sources of enlightenment on this topic and I appreciate their numerous hours of on-the-job training. The primary textbooks available at that time were the renowned tomes on facial flap reconstruction by Drs. Shan Baker and Ian Jackson, which contain requisite chapters on eyelids; however, I sought deeper knowledge specifically regarding the periocular area. Given this dearth of information, I vowed that someday I would write such a book.

In the intervening 20 years, there have been a few texts published that address this topic in more detail, including the well-known text titled Atlas of Oculofacial Reconstruction by Dr Gerald Harris. However, I feel that a space still remains for another textbook to provide a varied perspective on this topic, given that this is one of our most creative and challenging undertakings as periorbital surgeons.

I spend many hours each year reading the biographical personal statements of ophthalmology residents applying for ophthalmic plastic surgery fellowship. One of the most formative experiences that applicants comment upon - the one that clenched their decision to pursue ophthalmic plastic surgery training - was their involvement in a complex eyelid reconstruction case after tumor removal. They recall not only the genius-level of creativity they believe went into designing the flaps and grafts tailored to the defect, but also the satisfaction in restoring function and aesthetics to the human undergoing the surgery. Periorbital reconstruction is indeed one of the most rewarding surgeries that we perform as ophthalmic plastic surgeons, knowing that a sight- and life-threatening tumor has been eradicated, and that past training and experience have afforded the knowledge to repair the resulting tissue defect to the best of our ability. These are some of the most challenging procedures that we perform, because preparation beforehand is often not possible, given the unpredictable defects that we face after Mohs micrographic surgeons remove tumors or patients present with trauma.

I am fortunate to work with 3 outstanding colleagues at Massachusetts Eye and Ear on the Ophthalmic Plastic Surgery Service, Drs Michael Yoon, Daniel Lefebvre, and Grace Lee. When I proposed this textbook to them, all were enthusiastic to be co-editors and their diligent work on this text has made my dream come to fruition. I am also grateful to Thieme Medical Publishers and specifically Mr. William Lamsback and Ms. Elizabeth Palumbo for their support with this project.

This textbook is a compilation of our cases and experience over many years. It is targeted to benefit students, residents, fellows and experienced surgeons in the fields of ophthalmic plastic surgery, ophthalmology, otolaryngology, facial plastic surgery, plastic surgery, dermatology, Mohs surgery, and maxillofacial surgery who find the need to understand or improve their periocular reconstruction skills. The book is designed to be a logical and simple-to-use surgical reference – the type of book that can be pulled off the shelf when an instant decision is necessary on how to approach the tissue defect of a patient lying on the surgical table in the next room.

The layout of the chapters for this text was straightforward to formulate. A thorough understanding of the highly complex eyelid and periorbital anatomy is critical to performing safe and effective surgery, and this is covered in the first chapter. The second chapter discusses basic principles of performing surgery in the periorbital area. Since many of the tissue defects we repair are secondary to Mohs micrographic surgical excision of tumors, the third chapter provides a comprehensive overview of Mohs surgery in the periorbital area. The next four chapters divide the periorbital region into upper eyelid, lower eyelid, medial canthus and lateral canthus, providing a logical division of these unique areas, each requiring special considerations based on the underlying anatomy, adnexal structures and required functions. These chapters are filled with practical and concise descriptions of the procedures accompanied by numerous photographs and illustrations to enhance comprehension. Finally, the text would be remiss without discussion of periorbital trauma, which comprises the final chapter in the text.

We hope that readers will share our enthusiasm for maximizing their armamentarium of periorbital reconstruction skills with the information compiled in this one concise volume. By adhering to basic principles discussed in this text, even complex defects can be confidently and effectively repaired, resulting in optimal patient outcomes.

Suzanne K. Freitag, MD

1 Periocular Anatomy

Juan C. Jiménez-Pérez

Summary
A thorough understanding of eyelid and periocular anatomy is crucial for functional and aesthetic success in eyelid reconstruction after trauma, tumor excision, or any procedure that changes the normal eyelid architecture. Proficiency in restoring the eyelids takes experience as well as a fundamental knowledge of the anatomy that is presented in this chapter.

Keywords: eyelid anatomy, eyelid circulation, eyelid innervation, eyelid musculature

1.1 Eyelids

The main function of the eyelid is to protect the eye. The eyelids attach to orbital bones via the medial canthal tendon (MCT) and lateral canthal tendon (LCT) forming two opposite arches. The lateral canthus is usually approximately 2 mm higher than the medial canthus. The horizontal length of the eyelid is about 30 mm and the vertical aperture height (palpebral fissure) is about 10 mm. The adult upper eyelid rests about 1.5 mm below the superior limbus of the cornea, while the lower eyelid rests at the level of the inferior limbus. The peak of the upper eyelid is at the medial border of the pupil, and the lowest point of the lower eyelid margin is the lateral aspect of the pupil. The eyelid margin can be conceptually divided into anterior (skin and orbicularis muscle) and posterior (tarsus and conjunctiva) lamellae for the purposes of eyelid reconstruction.[1,2]

1.2 Eyelid Layers

The layers of the upper eyelid from anterior (superficial) to posterior (deep) are skin, orbicularis oculi muscle, orbital septum, preaponeurotic fat, levator palpebrae superioris muscle, Müller muscle, tarsus, and conjunctiva (▶ Fig. 1.1). It is important to understand that the different layers of the eyelid are not always present in all eyelid sections and vary by vertical height within the eyelid.

1.2.1 Skin

The eyelid skin is the thinnest in the body. It is composed of keratinized stratified squamous epithelium and has no subcutaneous fat. With aging, skin loses elasticity and becomes thinner due to breakdown of collagen. The upper eyelid crease is formed from levator aponeurosis attachments to the skin and pretarsal orbicularis oculi muscle. The crease is usually higher in women and Caucasians compared to men and Asians. The crease is approximately at the same height as the superior tarsal border in Caucasians. In Asians, it is about 4 mm above the eyelid margin due to a lower fusion of the orbital septum with the levator muscle, allowing the preaponeurotic fat to fall more anteriorly and inferiorly in the upper eyelid.[1,2]

1.2.2 Orbicularis Oculi Muscle

The orbicularis oculi muscle is the protractor of the eyelid. It extends from the upper and lower eyelid margin in a circumferential fashion to the superior and inferior orbital rims, respectively. It is anatomically divided into the palpebral (pretarsal and preseptal) and orbital portions (▶ Fig. 1.2). Innervation by the zygomatic and temporal branches of facial nerve (seventh cranial nerve) allows the muscle to contract and close the eyelids. The involuntary closure or blinking is mediated by the palpebral portion, whereas the voluntary closure is mediated by the orbital portion of the muscle. A portion of the orbicularis, the muscle of Riolan, is visualized along the middle of the eyelid margin, forming the gray line.[1,2]

1.2.3 Orbital Septum

The orbital septum is a thin, multilayered, inelastic, fibrinous tissue that demarcates the anterior extent of the orbital soft tissues. The orbital septum arises from the arcus marginalis, a dense periosteal fusion of orbital septum, periorbita, and pericranium that circumferentially lines the orbital rim (▶ Fig. 1.3). It inserts onto the upper and lower eyelid retractors and provides support. Aging causes septum attenuation allowing the orbital fat to move forward via pseudoherniation. The orbital septum is an important anatomical landmark that divides the superficial skin and orbicularis muscle from the deeper structures of the orbit and functions as a barrier to infections and spread of tumors.[1,2]

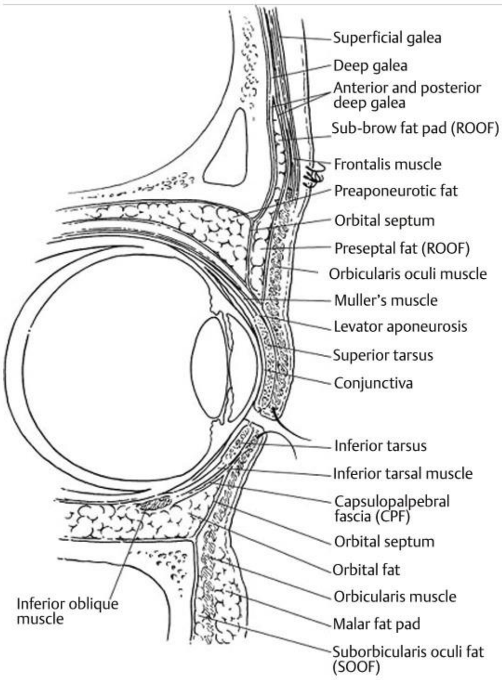

Fig. 1.1 Cross-section of the upper and lower eyelid anatomy. (From Chen WP, Oculoplastic Surgery: The Essentials. New York: Thieme Medical Publishers; 2001.)

1.2.4 Preaponeurotic Fat

The preaponeurotic fat is a relatively avascular collection of adipose tissue situated between the orbital septum anteriorly and levator palpebrae superioris muscle posteriorly. In the upper eyelid there are two fat pads: the medial and the central. They are each enclosed in a thin fibrous sheath. The medial fat pad is usually paler in color and smaller compared to the distinctly yellow central fat pad.[3] The lacrimal gland fills the analogous space in the lateral upper eyelid. The lower eyelid contains three fat pads: the medial, central, and lateral (▶ Fig. 1.4). When fat is visible through a traumatic eyelid laceration, it indicates that the injury has extended to a depth beyond the orbital septum. In such instances, after proper wound cleaning, exploration, and repositioning of fat, the septum must not be sutured so as to avoid cicatricial eyelid retraction.[4]

1.2.5 Retractor Muscles

Upper Eyelid Retractors

Opening of the upper eyelid is mediated by two muscles: the levator palpebrae superioris and Müller muscles. The levator muscle is responsible for the voluntary elevation of the upper eyelid and is the primary retractor muscle. It originates in the orbital apex from the periorbita of the lesser wing of the sphenoid bone just above the superior rectus muscle origin in the annulus of Zinn. The muscular portion measures 40 mm in length, while the aponeurosis is 14 to 20 mm in length. The muscle traverses in the superior orbit from the apex in an anterior direction until it interfaces with Whitnall

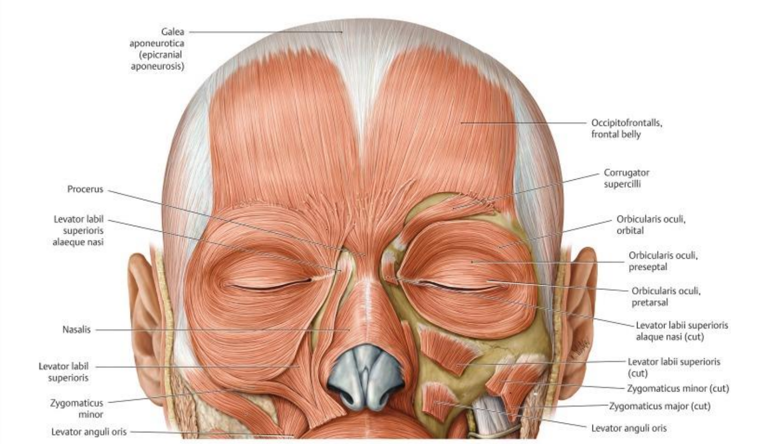

Fig. 1.2 The eyelid protractors. (From Watanabe K, Shoja MM, Loukas M, Tubbs RS. Anatomy for Plastic Surgery of the Face, Head, and Neck. New York: Thieme Medical Publishers; 2016.)

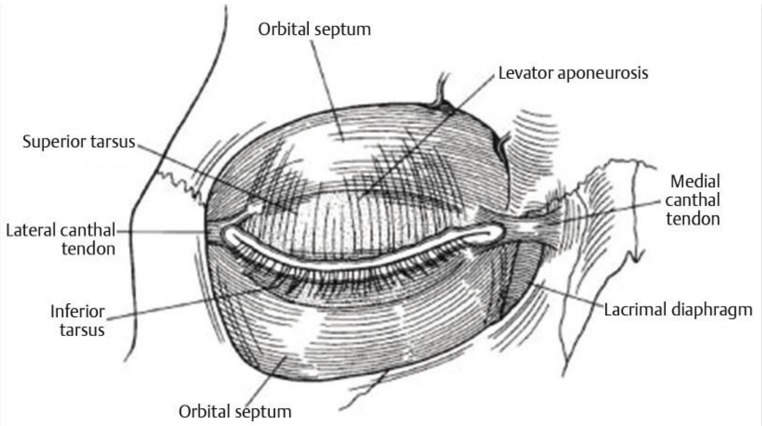

Fig. 1.3 The orbital septum. (From Wobig JL, Dailey RA. Oculofacial Plastic Surgery: Face, Lacrimal System, and Orbit. New York: Thieme Medical Publishers; 2004.)

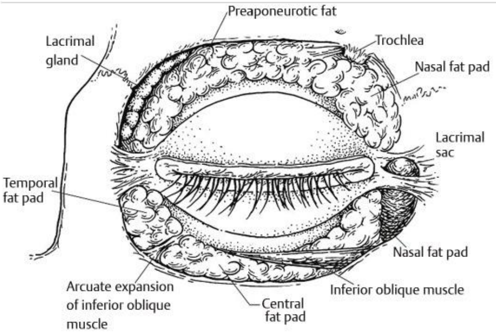

Fig. 1.4 The preaponeurotic fat. (From Chen WP, Oculoplastic Surgery: The Essentials. New York: Thieme Medical Publishers; 2001.)

ligament, where it changes to an inferior direction. The aponeurosis inserts onto the anterior tarsal surface with additional loose attachments to the skin creating the lid crease. As the aponeurosis travels inferiorly, it spreads out creating medial and lateral horns. The medial horn of the levator aponeurosis is thinner and more delicate than the lateral horn. The lateral horn divides the lacrimal gland into palpebral and orbital lobes (▶ Fig. 1.5). The muscle is innervated by the superior division of the oculomotor nerve (third cranial nerve).[1,2,5]

Müller muscle (superior tarsal muscle) is a smooth muscle innervated by sympathetic nerve fibers contributing approximately 2 mm of upper eyelid involuntary elevation. It originates from the deep surface of the levator aponeurosis at the level of Whitnall ligament and inserts at the superior tarsal border (▶ Fig. 1.5). The conjunctiva is deep to Müller muscle, and the peripheral vascular arcade is located superficial to the muscle above the superior tarsal border.[1,2]

Lower Eyelid Retractors

The lower eyelid retractors are analogous to the upper eyelid retractors, but less well defined. The equivalent of the levator aponeurosis is the capsulopalpebral fascia, which originates from the inferior rectus muscle fibers and then divides to encircle the inferior oblique muscle. Lockwood suspensory ligament forms anterior to the inferior oblique muscle and is somewhat analogous to Whitnall ligament in the upper eyelid (▶ Fig. 1.5). Terminal capsulopalpebral fascia fibers insert into

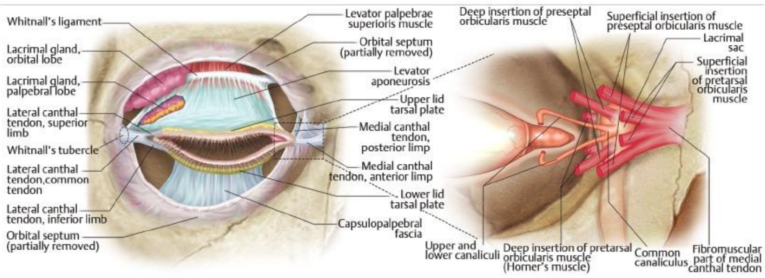

Fig. 1.5 The upper and lower eyelid retractors. (From Watanabe K, Shoja MM, Loukas M, Tubbs RS. Anatomy for Plastic Surgery of the Face, Head, and Neck. New York: Thieme Medical Publishers; 2016.)

both the inferior conjunctival fornix and the lower eyelid tarsus.[1,2,6] The lower eyelid analogue of Müller muscle is the inferior tarsal muscle, which originates from Lockwood ligament, travels between the capsulopalpebral fascia and conjunctiva, and inserts on the lower eyelid tarsus.[1,2,6]

1.2.6 Tarsus

The upper and lower eyelid tarsal plates are composed of dense fibrous tissue and provide structural rigidity to the eyelids. They attach firmly to the periosteum via the MCT and LCT. They measure about 1 mm in thickness and a maximum of 8 to 10 mm in vertical height in the central portion of the upper eyelid and about 4 mm in the lower lid, and taper medially and laterally as they attach to the canthal tendons (▶ Fig. 1.6). The Meibomian glands spiral vertically within the tarsal plates.[1,2]

1.2.7 Conjunctiva

The conjunctiva is a nonkeratinized squamous epithelium that covers the surface of the globe and the posterior surface of the eyelids. This mucous membrane is divided by location into palpebral, forniceal, and bulbar conjunctiva. It contains mucin-secreting goblet cells and the accessory lacrimal glands of Wolfring and Krause.[1,2]

1.3 Vascular and Lymphatic System

The vascular supply to the eyelids arises from the internal and external carotid artery branches and their extensive anastomoses. The internal carotid artery, via the ophthalmic artery, supplies the eyelid through the lacrimal artery, supraorbital artery, and medial palpebral arteries. The external carotid artery supplies the eyelid via the angular artery (terminal branch of the facial artery), infraorbital artery (branch of the maxillary artery), superficial temporal artery, and transverse facial artery (▶ Fig. 1.7). The complex and rich vascular supply contributes to rapid wound healing and a low incidence of infection following eyelid surgery. These arteries communicate to create the marginal arcades located on the anterior surface of the tarsus approximately 4 and 2 mm from the superior and inferior eyelid margins, respectively. They also create the superior peripheral arcade located between the levator aponeurosis and Müller muscle at the superior aspect of the tarsus. In the lower eyelid there may be a rudimentary peripheral arcade.[1,2]

The venous drainage of the eyelids is more diffuse. The tissue posterior to the tarsus drains into the orbital veins and the deeper branches of the anterior facial vein and pterygoid plexus. The tissue anterior to the tarsus drains medially through

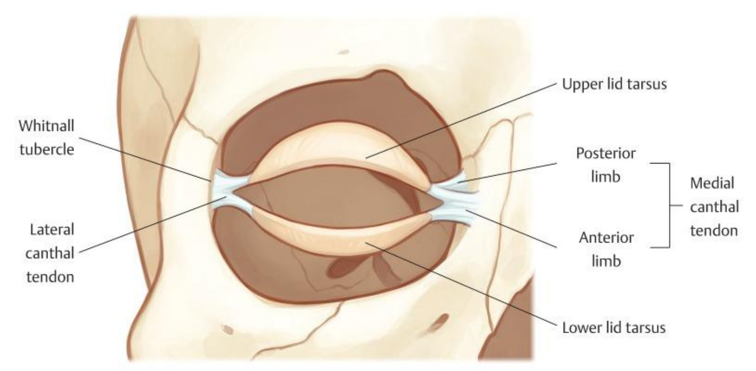

Fig. 1.6 The tarsus and canthal tendons.

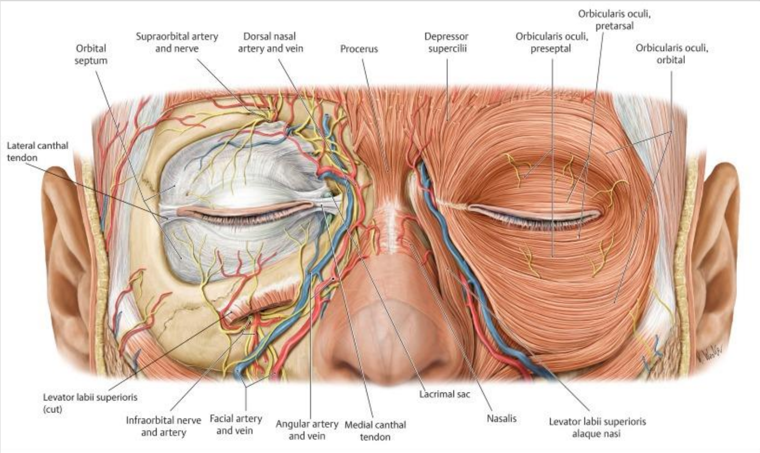

Fig. 1.7 The arterial and venous system. (From Watanabe K, Shoja MM, Loukas M, Tubbs RS. Anatomy for Plastic Surgery of the Face, Head, and Neck. New York: Thieme Medical Publishers; 2016.)

the angular vein and laterally through the superficial temporal vein (▶ Fig. 1.7).[1]

The lymphatic system drains through two systems. The medial aspect of the eyelids drains into the submandibular lymph nodes. The lateral aspect drains first into the superficial preauricular nodes and then into the deeper cervical nodes near the internal jugular vein.[1]

1.4 Nervous System

The nervous system of the eyelid may be divided into the sensory and motor nerves. The sensory innervation is derived from branches of the trigeminal nerve (fifth cranial nerve) (▶ Fig. 1.8). The ophthalmic division of the trigeminal nerve (V1) is divided into three primary branches: the lacrimal nerve that innervates the lateral aspect of the eyelid, the frontal nerve that innervates the medial upper eyelid and the superior portion of the medial canthus through the supratrochlear nerve, and the nasociliary nerve which innervates the inferior portion of the medial canthus through the infratrochlear nerve. The maxillary division of the trigeminal nerve (V2) innervates the lower eyelid through the infraorbital nerve. The zygomaticotemporal and zygomaticofacial nerve branches of the maxillary division of the trigeminal nerve (V2) supply sensation to the skin over the malar region and the lateral orbital rim.[2]

The motor innervation is through the temporal and zygomatic branches of the facial nerve (seventh cranial nerve) to the orbicularis oculi muscle (▶ Fig. 1.9). The superior division of the oculomotor nerve (third cranial nerve) supplies the levator palpebrae superioris, and the sympathetic fibers supply the superior and inferior tarsal muscles.

1.5 Lacrimal System

The lacrimal system is composed of the main and accessory lacrimal glands that produce aqueous tears and the drainage pathway of the tears. Tears are essential for eye lubrication. The tear film is composed of, in order from posterior to anterior, mucous, aqueous and oil layers, which allow tears to adhere to the surface of the eye, lubricate, and avoid rapid evaporation, respectively. The mucous component is made by goblet cells of the conjunctiva and the oil layer is produced by the sebaceous glands (Meibomian and Zeis) located mainly in the eyelids. Tears travel from the superolateral aspect of the eye to the medial aspect propelled by eyelid blinking. Blinking also helps create a pressure

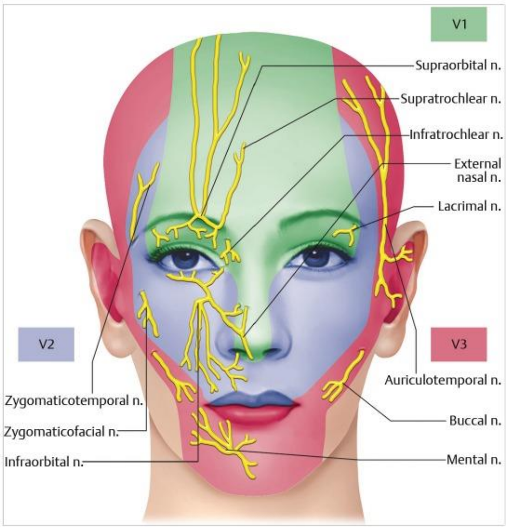

Fig. 1.8 The trigeminal nerve (CN V) cutaneous distribution. (From Watanabe K, Shoja MM, Loukas M, Tubbs RS. Anatomy for Plastic Surgery of the Face, Head, and Neck. New York: Thieme Medical Publishers; 2016.)

gradient to move tears through the nasolacrimal system.[2,7]

1.5.1 Lacrimal Gland

The lacrimal gland is an exocrine gland located in the lacrimal gland fossa of the frontal bone. It rests in the superolateral aspect of the orbit where it is divided by the lateral horn of the levator aponeurosis into two lobes: the deeper orbital lobe and the anteroinferior palpebral lobe (▶ Fig. 1.10a). The lacrimal ductules pass from the orbital lobe through the palpebral lobe to drain into the superior conjunctival cul-de-sac (▶ Fig. 1.10b). The lacrimal gland receives efferent innervation from the facial nerve as a branch that travels from the pons via the greater petrosal nerve. Parasympathetic synapse occurs in the pterygopalatine fossa and then these fibers track into the orbit through the inferior orbital fissure, eventually joining the lacrimal nerve (a sensory nerve of the trigeminal nerve) to enter the lacrimal gland for motor innervation.

1.5.2 Lacrimal Drainage System

The lacrimal drainage system begins with the punctum located in the medial aspect of the upper and lower eyelid margins. The orifice is slightly inverted and in contact with the tear film on the ocular surface. The upper puncta lie more medial than the lower puncta. Each punctum is situated on a surrounding elevation, the lacrimal papilla. After a 2-mm vertical pathway through the puncta, the lacrimal outflow pathway turns 90 degrees to form the canaliculi which run 8 to 10 mm horizontally. The canaliculi are lined by nonkeratinized stratified squamous epithelium and the lumen diameter measures 1 to 2 mm. In most cases the upper and lower canaliculi join together to form a common canaliculus before entering the lacrimal sac. The valve of Rosenmüller, at the distal aspect of the common canaliculus, prevents reflux from the sac back to the canaliculi. The lacrimal sac resides in the lacrimal sac fossa which is formed by the frontal process of the maxillary bone anteriorly and lacrimal bone posteriorly and is bound by the anterior and posterior lacrimal crests. The MCT surrounds the sac with the anterior limb inserting onto the anterior lacrimal crest and the posterior limb inserting onto the posterior lacrimal crest. The lacrimal sac measures 10 to 15 mm in vertical height with the superior third of the sac projecting above the

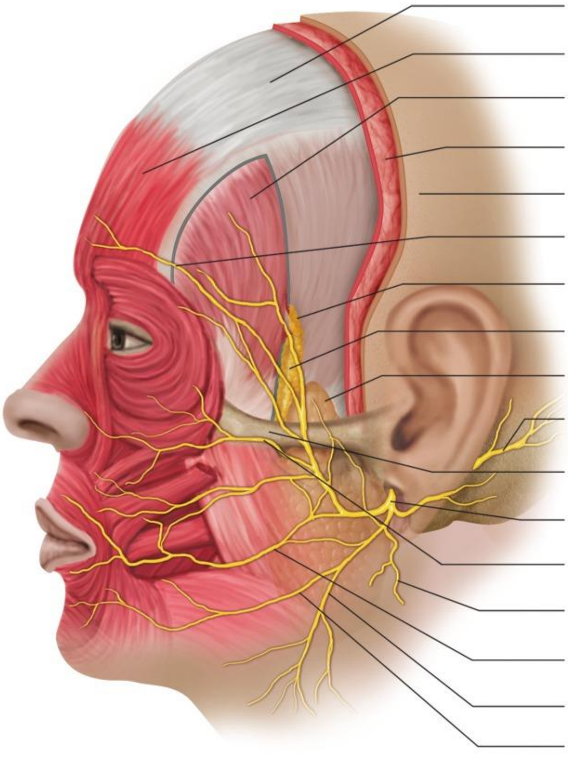

Fig. 1.9 The facial nerve (CN VII) distribution. (From Watanabe K, Shoja MM, Loukas M, Tubbs RS. Anatomy for Plastic Surgery of the Face, Head, and Neck. New York: Thieme Medical Publishers; 2016.)

MCT. The sac then narrows to become the nasolacrimal duct (NLD) measuring 12 to 18 mm in length. The NLD travels through the maxillary bone within the nasolacrimal canal in an inferior, posterior, and lateral orientation until it drains into the inferior meatus of the nose, under the inferior turbinate. The entrance of the NLD is partially covered by a mucosal fold known as the valve of Hasner (▶ Fig. 1.11).[2,7]

1.6 Accessory Structures

1.6.1 Canthal Tendons

The canthal tendons, measuring about 4 mm in length, are bands of fibrous tissue that are intimately associated with orbicularis muscle fibers and attach to the periorbita of the orbital rim.[2,8] The MCT originates from the medial aspects of the