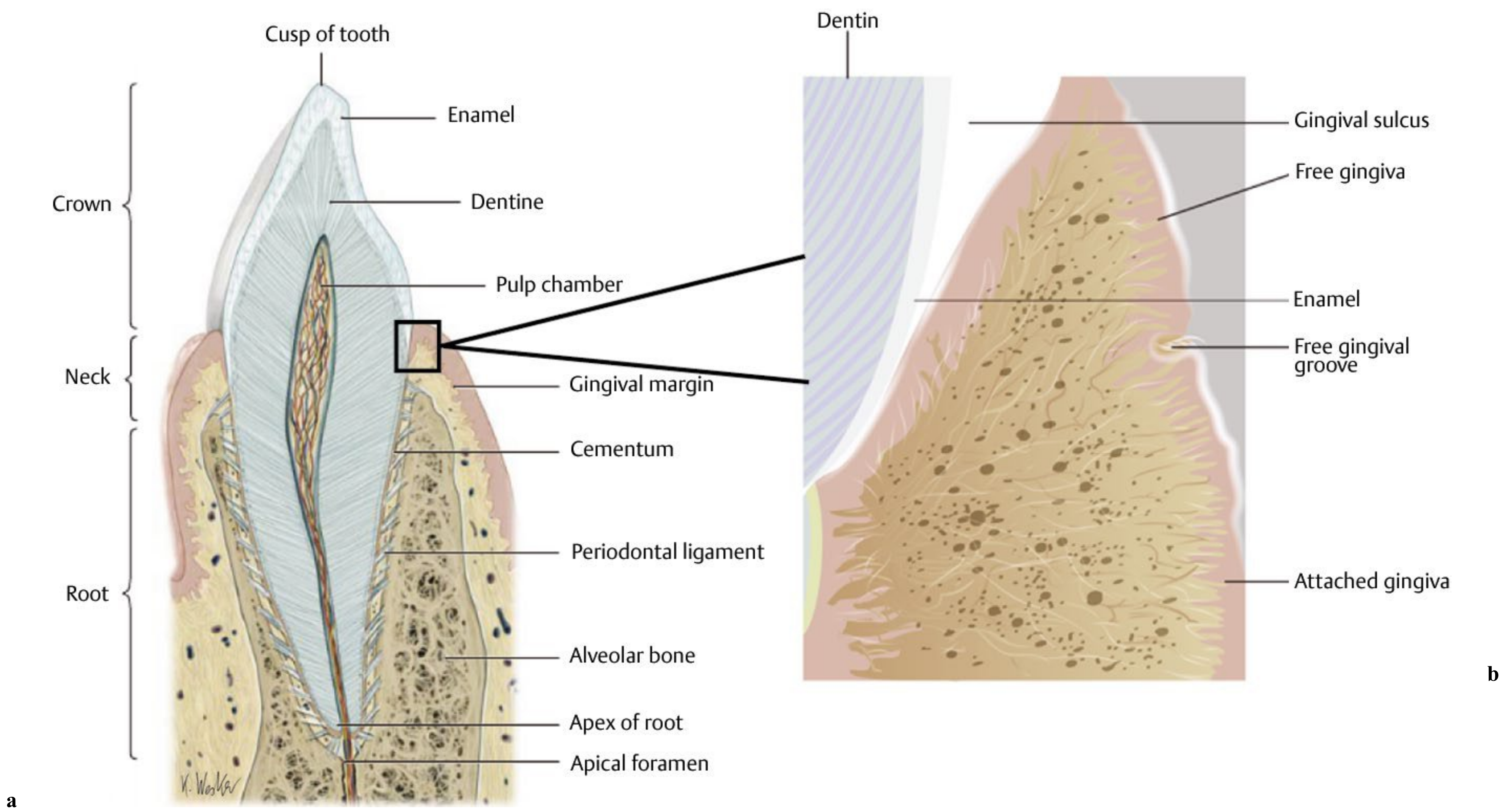


Fig. 20.6 **(a)** Longitudinal section of the incisor tooth and periodontal tissues. (Modified from THIEME Atlas of Anatomy, Head and Neck Anatomy for Dental Medicine. © Thieme 2010, Illustration by Karl Wesker.) **(b)** Magnified view of the rectangular zone in **(a)** showing the periodontal tissues of the neck region.

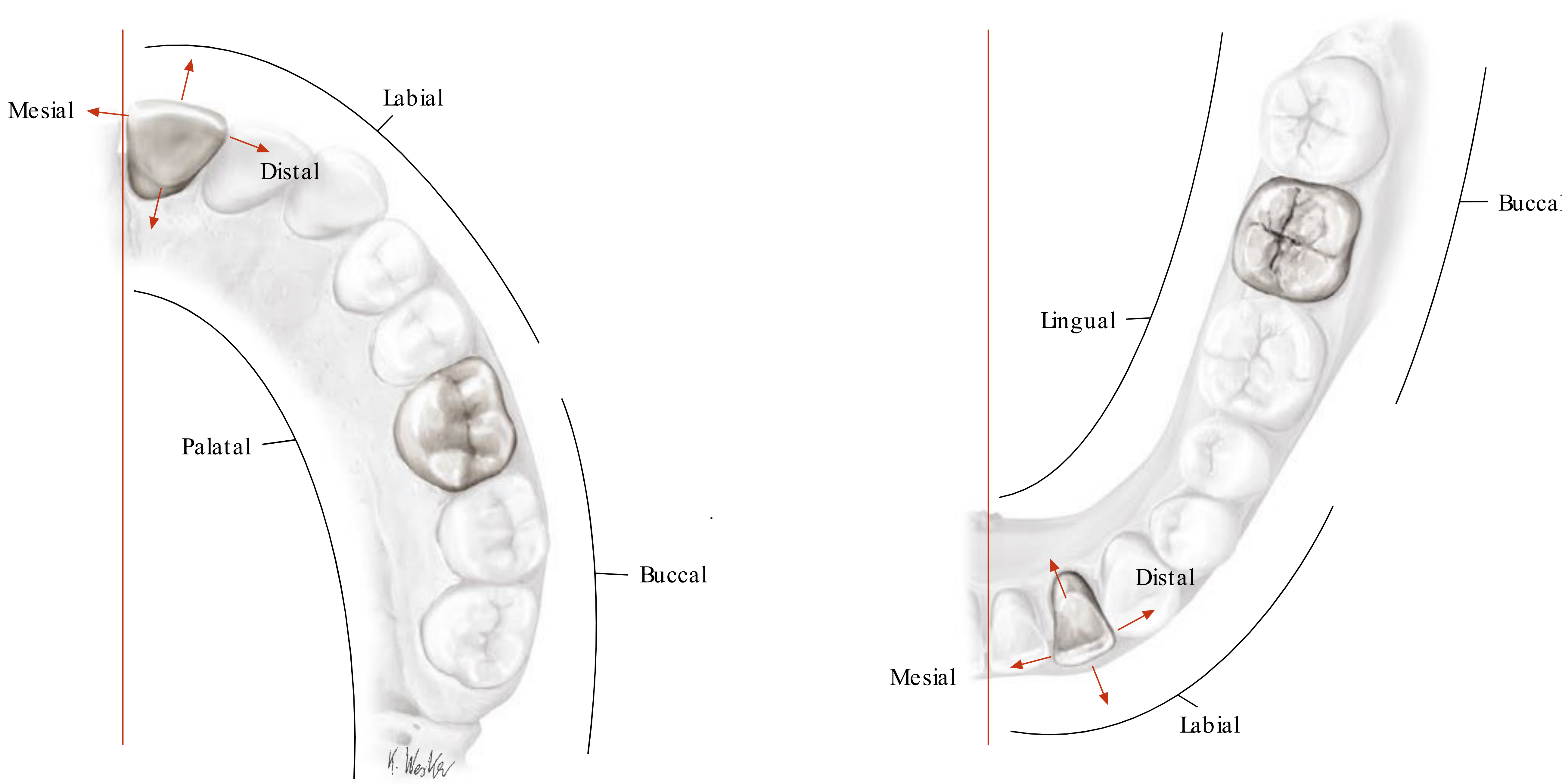


Fig. 20.7 Designation of surfaces of the teeth. **(a)** Inferior view of the maxillary teeth. **(b)** Superior view of the mandibular teeth. (Modified from THIEME Head and Neck Anatomy for Dental Medicine. © Thieme 2010, Illustrations by Karl Wesker.)

Table 20.1 Innervation of the oral mucosa

	Upper jaw	Dominant nerve	Lower jaw part	Dominant nerve
Labial or buccal mucosa	Anterior part	Infraorbital nerve, anterior superior alveolar branch	Anterior	Mental nerve
	Middle part	Buccal nerve	Middle	Buccal nerve
	Posterior part		Posterior	
Labial or buccal gingiva	Anterior part	Infraorbital nerve, anterior superior alveolar branch	Anterior	Mental nerve
	Middle part	Infraorbital nerve, middle superior alveolar branch	Middle	Buccal nerve
	posterior part	Infraorbital nerve, posterior superior alveolar branch	Posterior	
Palatal or lingual mucosa, gingiva	Anterior part	Nasopalatine nerve	Anterior part	Inferior alveolar nerve
	Middle part	greater palatine nerve (hard palate)	Middle part	
	Posterior part		Posterior part	

superior alveolar nerve. The lower teeth are innervated by the inferior alveolar nerve arising from the mandibular nerve. Both the upper and lower teeth are supplied by branches of the maxillary artery. The upper teeth are supplied by the anterior, middle, and posterior superior alveolar arteries, and the lower teeth are supplied by the inferior alveolar artery. The veins accompanying the maxillary artery drain the upper and lower jaw into the pterygoid venous plexus and collect the maxillary vein, deep facial vein, and buccal vein and then drain into the retromandibular vein and facial vein.

Gingiva/Alveolar Mucosa

The immobile and keratinized mucosa that surrounds the alveolar bone and coheres to the periosteum is called gingiva (**Table 20.1**). The mobile mucosa between the gingiva and the gingivobuccal fold is known as the alveolar mucosa and is not normally keratinized. The gingiva is further subdivided into free gingiva and attached gingiva by the free gingival groove (**Fig. 20.6**). Innervation of the lower gingiva and alveolar mucosa comes from the lingual, buccal, and mental nerves; innervation of the upper gingiva and alveolar mucosa comes from the nasopalatine, greater palatine, and buccal nerves (**Fig. 20.8a,b**).

Palate

The hard palate forms the roof of the oral cavity and is lined by bone (**Fig. 20.8b, Table 20.1**). The posterior soft part of the palate lacks bone, is called the soft palate, and consists of striated muscles. The border between the hard and soft palates is easy to visualize by having the patient say “Ah”; then only the soft palate vibrates. The posterior end of the soft palate is the palatine velum, in the middle of which the uvula hangs. The bony palate is formed by the maxillary bone in its anterior two-thirds and by the palatine bone in its posterior one-third. On the surface of the palatine mucosa are incisive papilla, transverse palatine folds, palatine raphe, and palatine foveolae. The mucosa of the hard palate is composed of the epithelium, proper lamina and submucosal tissue. The epithelium is keratinized, and the proper lamina is thick and filled with connective tissue in the anterior part of the hard palate. The submucosal tissue of the incisive papilla and the transverse palatine folds are filled with fat tissue, but the palatine raphe lacks submucosal tissue. If the palatine torus exists, the palatine mucosa is so thin that it is easily injured and may form ulcers caused by physical and chemical damage. Palatine glands are present at the posterior surface of the soft palate. Many taste buds are also located in the soft palate. The incisive fossa is just under the incisive papilla and ascends to the incisive canal. The nasopalatine artery, vein, and nerve run through the incisive canal; so care needs to be taken when incising over the incisive papilla. The greater palatine foramen is located 15 mm lateral to the palatine raphe, between the second and third molar. The greater palatine artery and nerve run to the anterior part of the hard palate from the greater palatine foramen, so it is risky to incise the palate transversely. Many clinicians have reported cases in which repair of an oroantral fistula was undertaken using the palatine mucosa for the axial pattern flap and using the greater palatine artery as a feeding vessel.[5] The muscles that form the soft palate are described in the section on swallowing.

Tongue

The tongue is a muscular organ, arising from the oral floor and spreading into the oral cavity proper (**Fig. 20.9**). The intrinsic muscles change the shape of the tongue, and the extrinsic muscles move the tongue and intersect and play important roles in mastication, swallowing, and speech. In addition, one of the most important functions of the tongue is as a taste receptor. Three cranial nerves convey the taste fibers: CN VII (facial nerve, chorda tympani branch), CN IX (glossopharyngeal nerve),

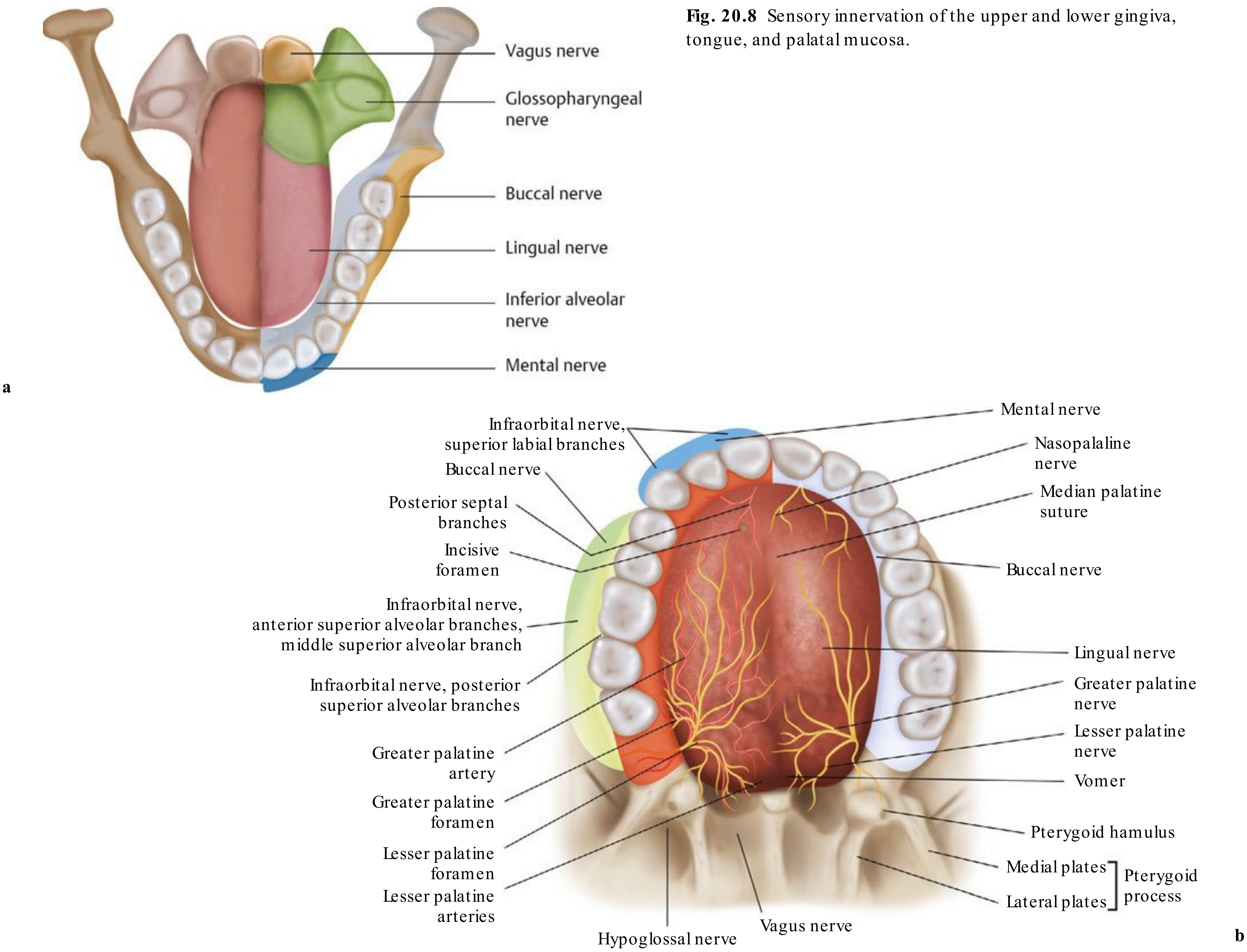


Fig. 20.8 Sensory innervation of the upper and lower gingiva, tongue, and palatal mucosa.

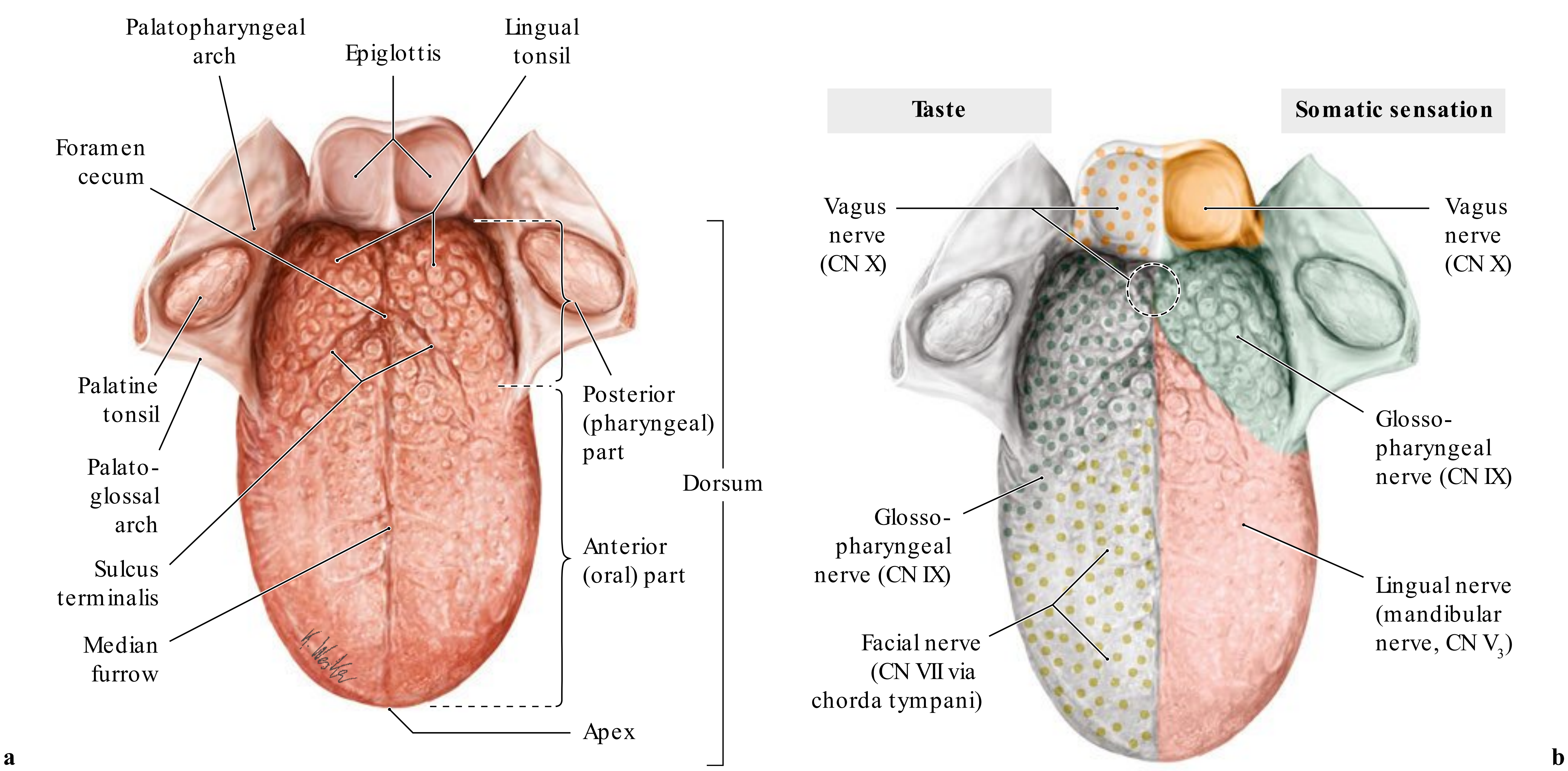
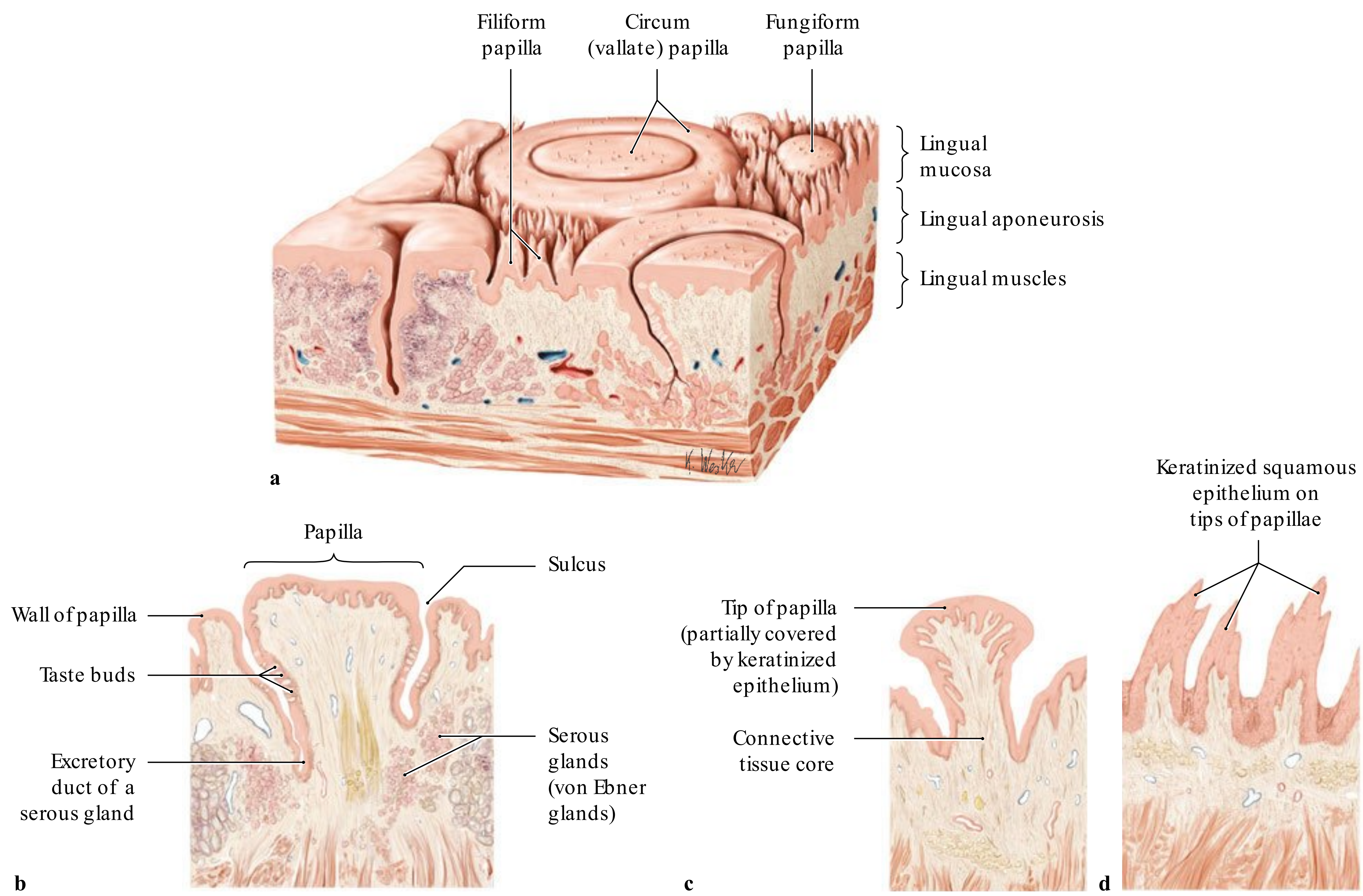


Fig. 20.9 **(a)** Surface anatomy of the lingual mucosa. **(b)** Somatosensory innervation (left side) and taste innervation (right side) of the tongue. (Modified from THIEME Head and Neck Anatomy for Dental Medicine. © Thieme 2010, Illustrations by Karl Wesker.)

and CN X (vagus nerve). Thus, a disturbance in taste sensation involving the anterior two-thirds of the tongue indicates the presence of a facial nerve (chorda tympani) lesion, whereas a disturbance of somatic sensation indicates a lingual nerve lesion.

On the dorsal mucosa of the tongue are four kinds of papillae: filiform papillae, fungiform papillae, foliate papillae, and circumvallate papillae (**Fig. 20.10**). Filiform papillae are the smallest and are distributed over the whole anterior two-thirds of the tongue; they are the only papillae that have no taste buds. They are keratinized and white. Fungiform papillae exist predominantly at the lingual apex and sometimes have taste buds. They are not keratinized, so they take on the red color of the capillary vessels. Foliate papillae are the four to seven folds located on the posterolateral region of the tongue. In adults, the taste buds in the foliate papillae degenerate. Serous glands lie under the foliate papillae for the purpose of cleaning the taste buds. Approximately 10 circumvallate papillae are positioned in front of the terminal sulcus and form a V-shaped line. They are the largest tongue papillae (3 mm in diameter) and are surrounded by a deep groove in which there are taste buds in the epithelium. In adults, approximately two-thirds of the taste buds are on the tongue. The soft palate also has many taste buds. Innervation of the anterior two-thirds of the tongue comes from the chorda tympani, and the posterior third is innervated by the glossopharyngeal and vagus nerves. Therefore, it is known that if these nerves are injured by surgical procedures, chemotherapy, or radiotherapy, dysgeusia may occur. It is difficult to examine the root of the tongue when the mouth is open. In cases of ankyloglossia, in which the lingual frenulum is too rigid to allow movement of the tongue and speech is hampered, lingual frenoplasty might be necessary. The deep lingual artery and vein and the lingual nerve are situated on the inferior surface of the tongue, so sensory paralysis and bleeding may occur if they are injured. In particular, care should be taken not to injure the deep lingual vein because of its position directly under the mucosa (**Fig. 20.11**). If the tongue is extended, the border between



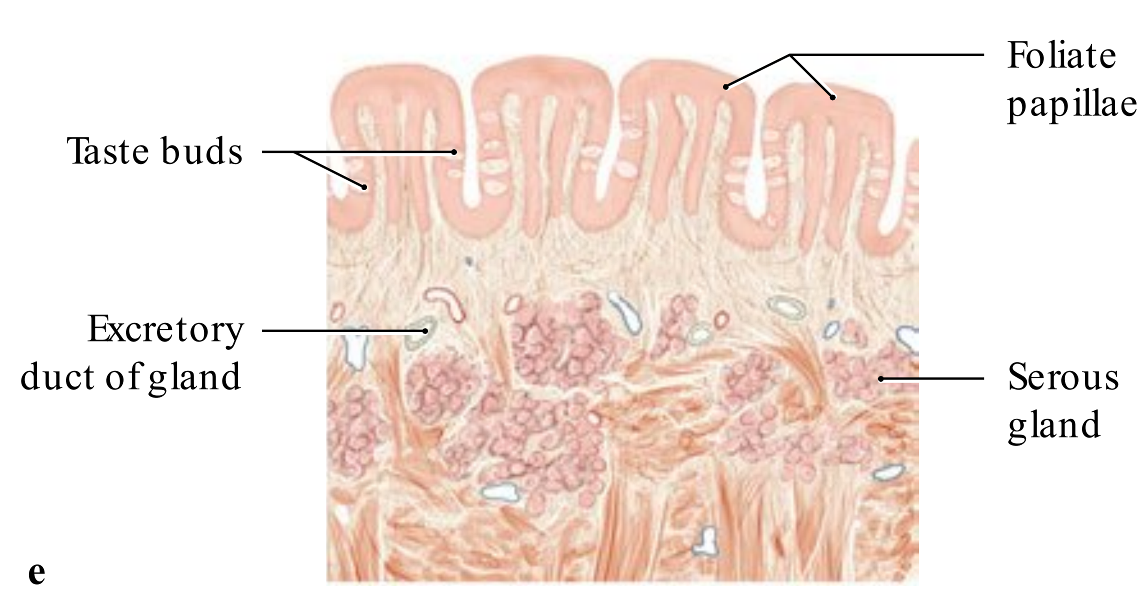
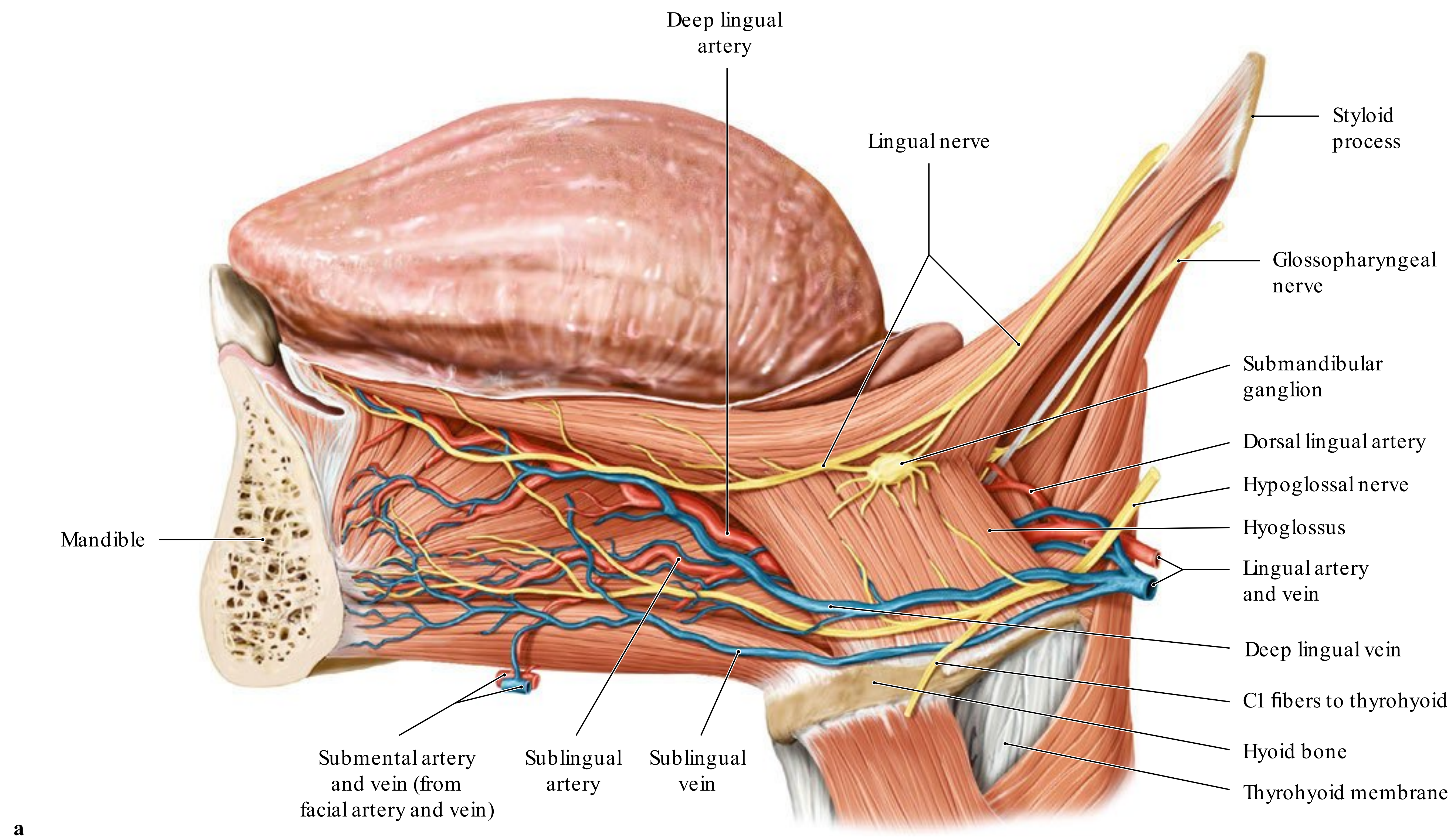


Fig. 20.10 Papillae of the tongue. **(a)** Sectional block diagram of the lingual papillae. **(b)** Circumvallate papillae. **(c)** Fungiform papillae. **(d)** Filiform papillae. **(e)** Foliate papillae. (From THIEME Head and Neck Anatomy for Dental Medicine. © Thieme 2010, Illustrations by Karl Wesker.)



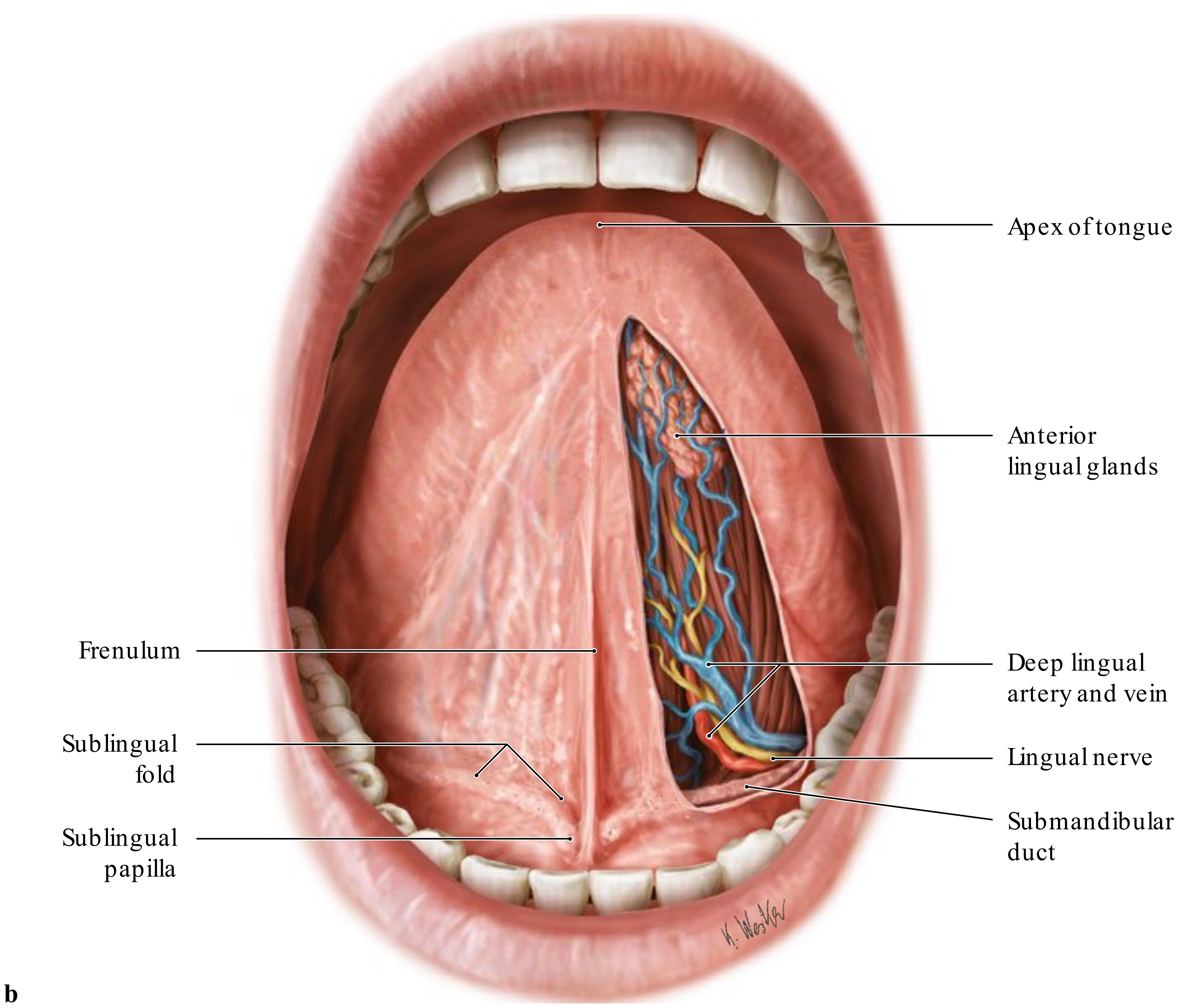


Fig. 20.11 Nerves and vessels of the tongue. **(a)** Left lateral view. **(b)** View of the inferior surface of the tongue. (From THIEME Head and Neck Anatomy for Dental Medicine. © Thieme 2010, Illustrations by Karl Wesker.)

the inferior surface of the tongue and the oral floor is hard to see. It is well known that there are communicating branches between the lingual and hypoglossal nerves in the body and apex of tongue; however, their physiologic function is not fully understood.[6]

Buccal Fat Pad

The buccal fat pad (anatomically, the corpus adiposum buccae) is the fat located deep in the cheek region (**Fig. 20.12**). This fat is also called Bichat's fat pad and is named after the French anatomist who first recognized the nature of this tissue. The buccal fat pad is located between the muscles of mastication in what is called the masticatory space and has a role in facilitating the smooth gliding of the masticatory muscles. It also forms the shape of the bulge of the cheek.

According to Stuzin et al, the buccal fat pad consists of a main body and three extensions: buccal, pterygoid, and temporal.[7] The main body is the part above the parotid duct and is located superficial to the buccinator and anterior to the anterior edge of the masseter. It also extends medially to the posterior part of the maxilla. At the superior and medial section, it touches the maxillary artery and the maxillary nerve (a branch of the trigeminal nerve). The buccal extension is the superficial segment located along the anterior edge of the masseter and beneath the parotid duct. The buccal branches of the facial nerve run over this extension. At the anterior border, the facial artery and vein run obliquely. The pterygoid extension is in the area between the ramus of mandible and the pterygoid muscles. The temporal extension passes beneath the anterior part of

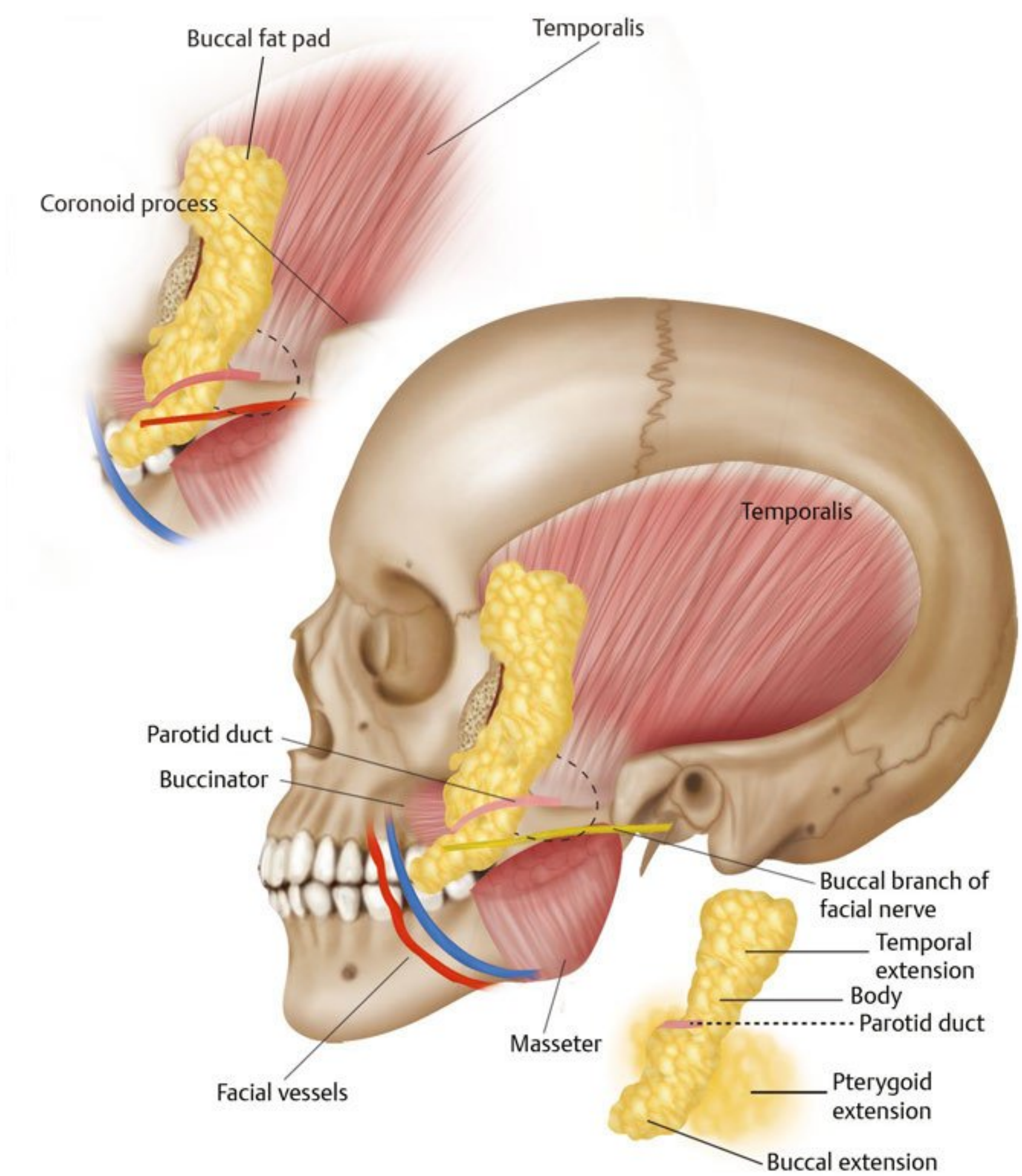


Fig. 20.12 Buccal fat pad. The buccal fat pad consists of a main body and three extensions: buccal, pterygoid, and temporal. The main body is the part above the parotid duct and is located superficial to the buccinator and anterior to the anterior edge of the masseter. The buccal extension is the superficial segment located along the anterior edge of the masseter and beneath the parotid duct. The pterygoid extension is in the area between the ramus of mandible and the pterygoid muscles. The temporal extension passes beneath the anterior part of the zygomatic arch and lies between the temporalis muscle and the deep temporal fascia.

the zygomatic arch and lies between the temporalis muscle and the deep temporal fascia.

The buccal fat pad is used in free grafts and pedicle flaps for various tissue defects, most commonly for the repair of oroantral fistulae and also for the treatment of other oral cavity tissue defects, ranging from the angle of mouth to the retromolar trigone and palate.[8]

Floor of Mouth and Sublingual Space

The floor of the mouth is the region surrounded by the lower alveolus and the tongue. The submucosal tissue of the floor of the mouth is composed of sparse connective tissue and is highly mobile. The floor of the mouth is divided into two parts by the lingual frenulum. The submandibular duct (Wharton's duct) opens at the sublingual caruncle after joining the greater sublingual duct, and many lesser sublingual ducts open at the sublingual fold posterior to the sublingual caruncle. Beneath the floor of the mouth is a sublingual space located superior to the mylohyoid muscle and on the lateral side of the genioglossus and geniohyoid muscle. The contents of this space are the sublingual gland; the submandibular duct; the greater and lesser sublingual ducts; the lingual nerve, artery, and vein; and the hypoglossal nerve. This space is therefore quite important in clinical situations. The submandibular duct arises from the submandibular gland, which is located posterior to the end of the mylohyoid muscle and runs to the sublingual caruncle. On the proximal part of the submandibular duct, the lingual nerve traverses inferior to the submandibular duct and is then distributed to the tongue. The reported incidence of sublingual gland protrusion through defects in the mylohyoid muscle is approximately 25 to 40%[9] Care should be taken around this area, as the submental artery (a branch of the facial artery) and the sublingual artery (a branch of the lingual artery) travel into the dorsal side of the midline of the mandible at the lingual foramen. There are many variations of anastomoses of the submental and sublingual arteries.[10]

Oropharyngeal Isthmus

The oropharyngeal isthmus forms the border of the oral cavity and the pharynx and is the posterior end of the oral vestibule (**Fig. 20.2**). The posterior end of the soft palate forms the palatine velum with a median process known as the uvula. Two folds run laterally downward from the palatine velum. The anterior fold is the palatoglossal arch, and the posterior fold is the palatopharyngeal arch. The palatine tonsils are situated between these two folds on both sides.

Pharynx

The pharynx is the digestive tube located between oral cavity and the esophagus, posterior to the oral and nasal cavity. The pharyngeal cavity is the intersection of the digestive tract and the respiratory system. The pharynx is composed of the epi(naso)pharynx, oropharynx, and hypopharynx. The epipharynx is positioned dorsal to the posterior nasal apertures at the back end of the nose; the pharyngeal opening of the auditory tube, which is connected with the tympanum opens in the lateral wall; and the pharyngeal tonsil is located in the posterior wall. Waldeyer's ring is composed of the palatine tonsil, the lingual tonsil, and the pharyngeal tonsil, and it comprises immunocompetent lymphatic tissue. This is the first biophylaxis against foreign invasion. The oropharynx is located posterior to the oral cavity, and the hypopharynx communicates with the laryngeal cavity through the laryngeal aperture.

Swallowing

The act of eating and swallowing, which is required for the intake of food, can be easily explained by dividing it into five stages: the awareness phase (preliminary phase), the preparatory phase (chewing phase), the oral cavity phase, the pharyngeal phase, and the esophageal phase. In the awareness phase, the body becomes aware of food and creates a natural eating pace. During the preparatory phase, food placed in the mouth is chewed and mixed to create a food bolus in a condition that can be swallowed. During the oral cavity phase, the bolus thus created is transferred from the mouth to the throat, after which it moves from the throat to the esophagus during the pharyngeal phase. During the esophageal phase, it is transferred from the esophagus to the stomach in a process of continual movement (**Fig. 20.13**).[11] Reports note cases in which food is transferred into the oropharynx during chewing, before the swallowing reflex begins,[12–15] and in which repeated swallowing results in a pattern in which the larynx is elevated.[16,17] During swallowing, many muscle groups, including the mimetic muscles surrounding the oral cavity, masticatory muscles, tongue muscles, palate

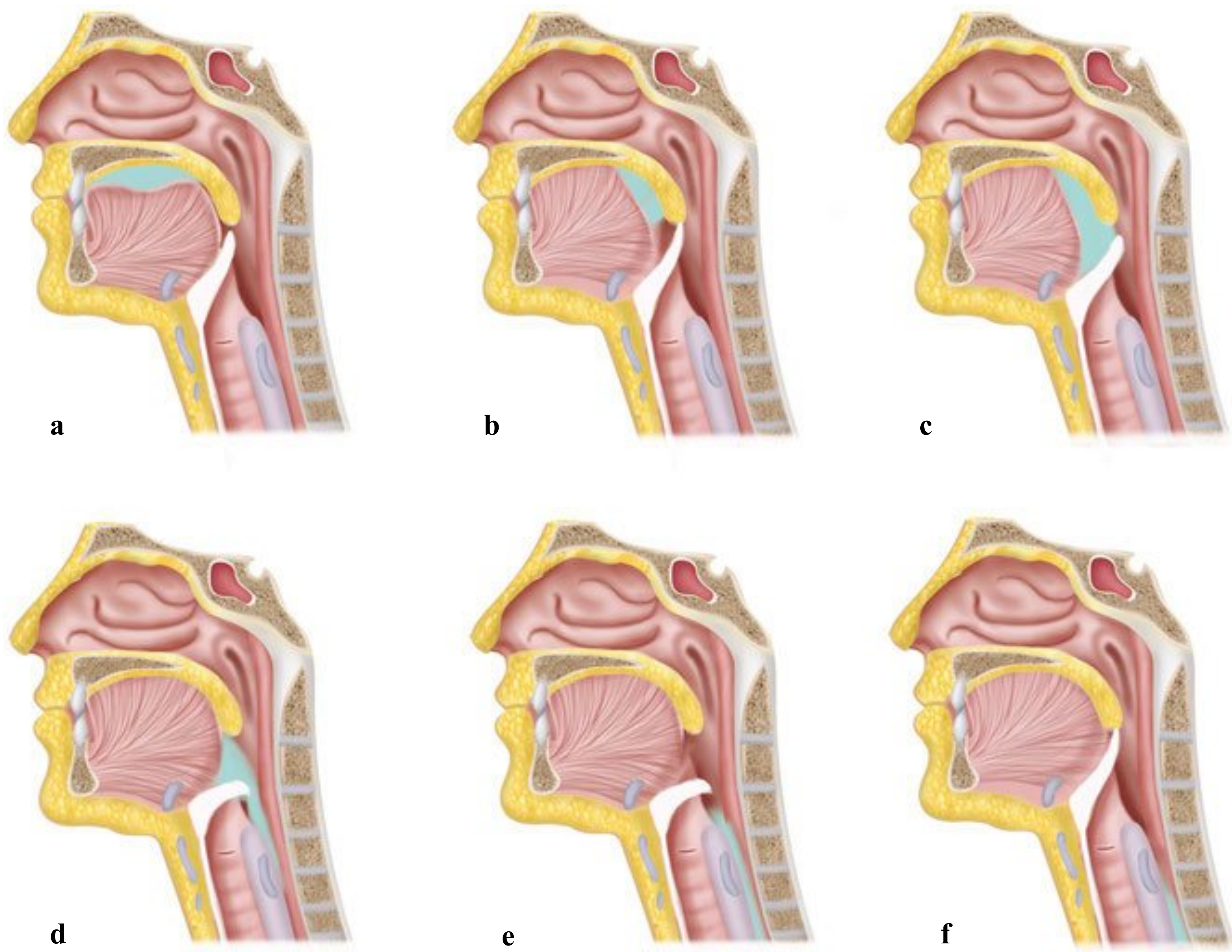


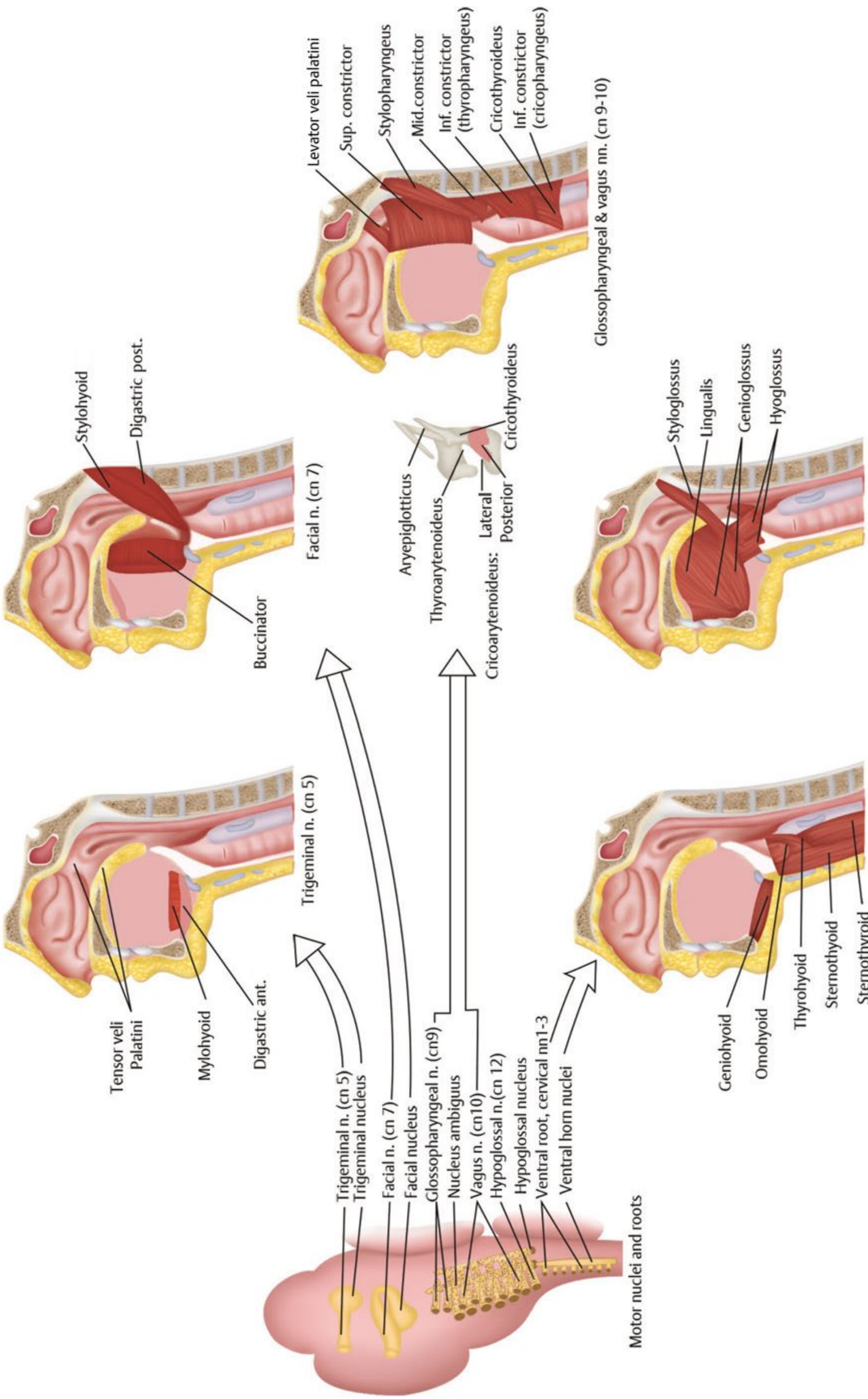
Fig. 20.13 Schematic diagram of swallowing. **(a)** Retention of the food bolus in the oral cavity. **(b)** Immediately before the beginning of the swallowing reflex. **(c)** Food bolus moves to the oropharynx. **(d)** Food bolus moves from the lower pharynx to the esophageal entrance. **(e)** Food bolus passes through the esophageal entrance. **(f)** Food bolus moves from the esophagus to the stomach.

muscles, upper and lower hyoid muscles, the pharyngeal muscle, and laryngeal muscle, all work together, with these muscles controlled by the trigeminal nerve, facial nerves, glossopharyngeal/vagus nerve, hypoglossal nerve, and cervical nerves, which receive instructions from the mastication and swallowing center. In this section, we present an explanation of swallowing movement from the preparatory phase onward, based mainly on the muscles related to swallowing.

Mechanism of Swallowing and the Involved Muscles

Preparatory Phase (Chewing and Food Bolus Formation)

The food taken into the oral cavity is formed into a food bolus by the tongue if it does not require chewing (**Fig. 20.13a, Fig. 20.14e**).[11] Food that requires chewing is broken down by the action not only of the tongue but also of the jaw and cheeks, and then it is mixed with saliva. When chewing begins, the food is swiftly positioned on the molars and chewed by the subsequent raising action of the jaw while being held in place by the expression muscles, mimetic muscles such as the cheek and tongue muscles (**Fig. 20.14b–e, Fig. 20.15**). The lower jaw closes when the masseter muscle, temporalis muscles, and medial pterygoid muscles on both sides contract; moves forward when the anterior lateral pterygoid muscle contracts; and rotates when the lateral pterygoid muscle on one side contracts (**Fig. 20.14b, Fig. 20.16**). It opens as a result of the movement of the lateral pterygoid muscle and suprahyoid muscle. The tongue contains intrinsic and extrinsic muscles (**Fig. 20.14e**), with movement of the intrinsic muscles causing it to contract or become long and thin or wide and flat. Of the extrinsic muscles, the genioglossus muscle protrudes the tongue; the styloglossus muscle raises the posterior aspect of the tongue, along with the palatoglossal muscle. The genioglossus muscle and the styloglossus muscle move together to retract the tongue. The hyoglossus muscle works to move the sides of the tongue downward; the tongue is lowered by the genioglossus muscle and hyoglossus muscle. When a food bolus is formed within the oral cavity, a depression is created in the center of the tongue, which “holds” the food bolus, requiring the soft palate and the tongue to be close



Motor nuclei and roots
Trigeminal n. (cn 5)
Trigeminal nucleus
Facial n. (cn 7)
Facial nucleus
Glossopharyngeal n. (cn9)
Nucleus ambiguus
Vagus n. (cn10)
Hypoglossal n.(cn 12)
Hypoglossal nucleus
Ventral root, cervical nn1-3
Ventral horn nuclei
Tensor veli Palatini
Mylohyoid
Digastric ant.
Trigeminal n. (cn 5)
Stylohyoid
Digastric post.
Buccinator
Facial n. (cn 7)
Levator veli palatini
Sup. constrictor
Stylopharyngeus
Mid.constrictor
Inf. constrictor (thyropharyngeus)
Cricothyroideus
Inf. constrictor (cricopharyngeus)
Glossopharyngeal & vagus nn. (cn 9-10)
Aryepiglotticus
Thyroarytenoideus
Cricoarytenoideus:
Lateral
Posterior
Cricothyroideus
Geniohyoid
Omohyoid
Thyrohyoid
Sternothyoid
Sternothyroid
Cervical nn. 1-3
Styloglossus
Lingualis
Genioglossus
Hyoglossus
Hyoglossal n. (cn 12)

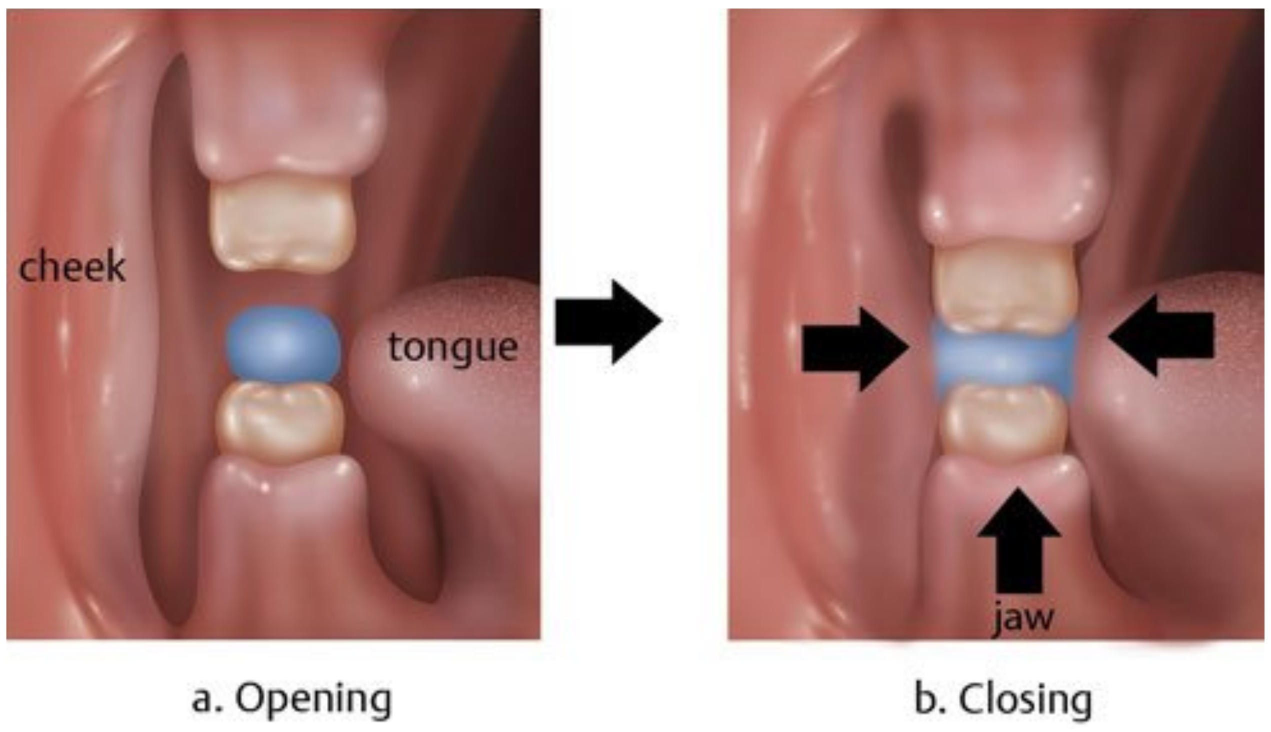


Fig. 20.15 Schematic diagram of the movement of the cheeks, tongue, and lower jaw during chewing.

to one another. To facilitate this action, the tongue takes on the formation of a spoon and is elevated at the back by the styloglossus muscle; the soft palate is drawn toward the tongue by the palatoglossal and palatopharyngeal muscles (**Fig. 20.14d, Fig. 20.17**).[18]

End of the Oral Cavity Phase and Beginning of the Pharyngeal Phase

The food bolus in the oral cavity is transferred to the pharynx; immediately before the pharyngeal phase begins, the intrinsic and extrinsic tongue muscles cause the tongue to adhere to the palate, gripping the food bolus so that it is moved towards the pharynx (**Fig. 20.13b**). From the start of the transfer (oral cavity phase), the action becomes reflexive, and voluntary control becomes impossible. When the transfer is finally implemented, the lower jaw and the lips are usually closed. At the same time, to prevent the food bolus from passing into the nasopharynx, the soft palate is elevated by the tensor and levator muscles of the palatine velum (**Fig. 20.14b,d, Fig. 20.17**); furthermore, contraction of the pharyngeal contractor causes the formation of Passavant's ridge, resulting in the upper pharynx being firmly closed (**Fig. 20.14d, Fig. 20.17**).

The food then begins to be passed into the pharynx, and the swallowing reflex begins, at which point the hyoid bone begins to be elevated (**Fig. 20.18**). The hyoid bone moves slightly backward at first, after which it begins to move upward, and then finally strongly forward and downward. The rearward movement of the hyoid bone at the start is furthermore believed to be caused by contraction of the stylohyoid muscle and the posterior belly of the digastric muscle (**Fig. 20.14c, Fig. 20.18**).

Pharyngeal Phase (Food Bolus Moves to the Oropharynx)

With the soft palate still elevated, the food bolus is pushed out from the base of the tongue to the oropharynx (**Fig. 20.13c, Fig. 20.14b,c**), at which point the upper pharyngeal and oropharyngeal contractors begin to contract (**Fig. 20.14d**), causing the hyoid bone and larynx to move toward their highest position (**Fig. 20.14d, Fig. 20.18**). Once the hyoid bone is elevated, the mylohyoid muscle and the anterior belly of the digastric muscle move the hyoid bone upward while the geniohyoid muscle moves the hyoid bone forwards (**Fig. 20.14b,f**). It is believed that these actions together cause elevation of the hyoid bone (**Fig. 20.14f**). Next, the thyrohyoid muscle contracts to elevate the larynx. At the same time as the elevation of the larynx, the pharyngeal constrictor muscles implement peristaltic constriction from the upper to the lower pharynx to transfer the food from the pharynx into the esophagus. Contraction in the oropharynx is caused not only by the pharyngeal constrictor action but also by the base of the tongue, which forms the pharyngeal anterior wall, moving toward the rear (**Fig. 20.14e**).

Furthermore, during the swallowing reaction, the glottis is closed by the action of the laryngeal intrinsic muscles, inhibiting the airway (**Fig. 20.14d, Fig. 20.19**). The laryngeal muscles and lateral thyroarytenoid muscles both act to adduct the vocal cords; however, the thyroarytenoid muscle shortens the vocal cords by contracting inward, and the lateral thyroarytenoid

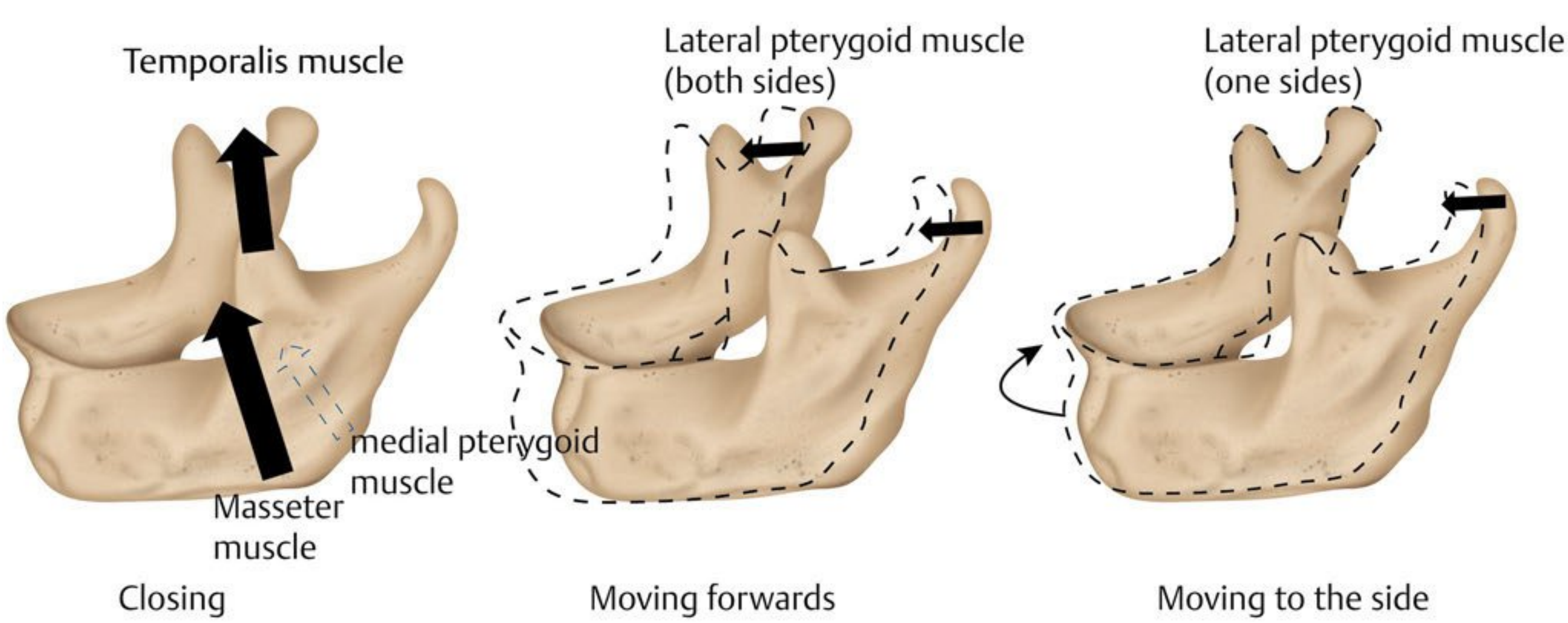


Fig. 20.16 Movements of the mandible by attached muscles.

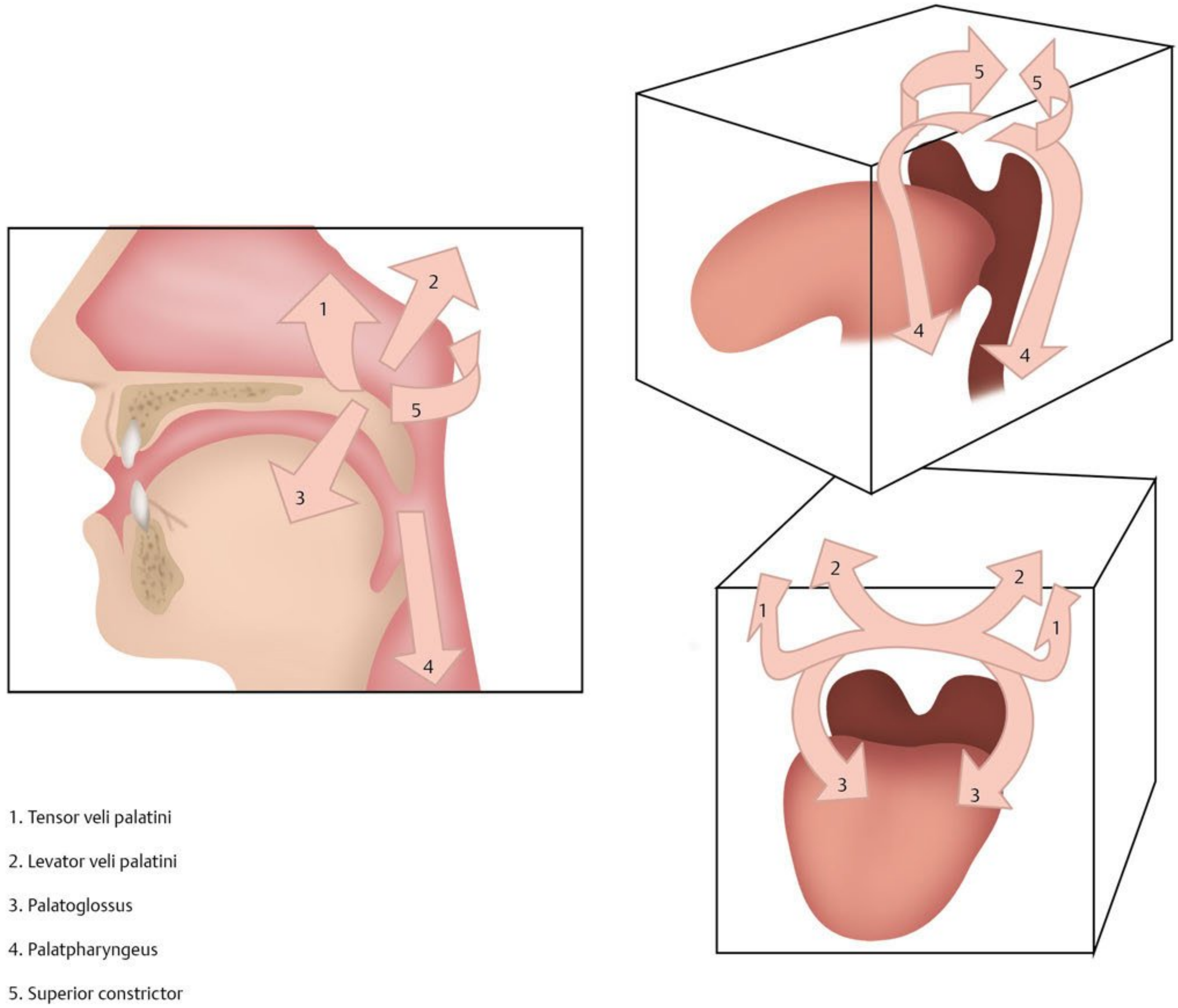


Fig. 20.17 Schematic diagram of velopharyngeal muscles action during speech. 1, Tensor veli palatini; 2, levator veli palatini; 3, palatoglossus; 4, palatpharyngeus; 5, superior constrictor.

muscle lengthens the vocal cords by contracting outward. Because the interarytenoid muscles also adduct the vocal cords, the posterior cricoarytenoid muscle is the only muscle that abducts the vocal cords. In addition, the cricothyroid muscle causes the thyroid cartilage and cricoid cartilage to approach one another, stretching the vocal cords and raising the pitch of the voice (**Fig. 20.14d**).

Pharyngeal Phase (Food Bolus Moves from the Lower Pharynx to the Esophageal Entrance)

The action of the suprahyoid and infrahyoid muscles results in the hyoid bone being moved as far upward and forward as possible, bringing the hyoid bone close to the larynx (**Fig. 20.20**). Pharyngeal contraction reaches the oropharynx, and the action of the palatopharyngeal and palatoglossal muscles lowers the soft palate (**Fig. 20.13d, Fig. 20.14d,f, Fig. 20.18**). The glottis remains closed, and contraction of the aryepiglottic muscle results in the epiglottis and arytenoid cartilage being brought close together, narrowing the entrance to the larynx (**Fig. 20.14d**). The further rearward movement of the base of the tongue and the downward pressure from above on the food that has been swallowed result in the epiglottis collapsing inward, closing the larynx and preventing foreign bodies from entering the airway during swallowing and temporarily stopping breathing (swallowing apnea). With the larynx closed, the food bolus passes through the lower pharynx on the side of the larynx. The base of the lower pharynx features depressions to the left and right

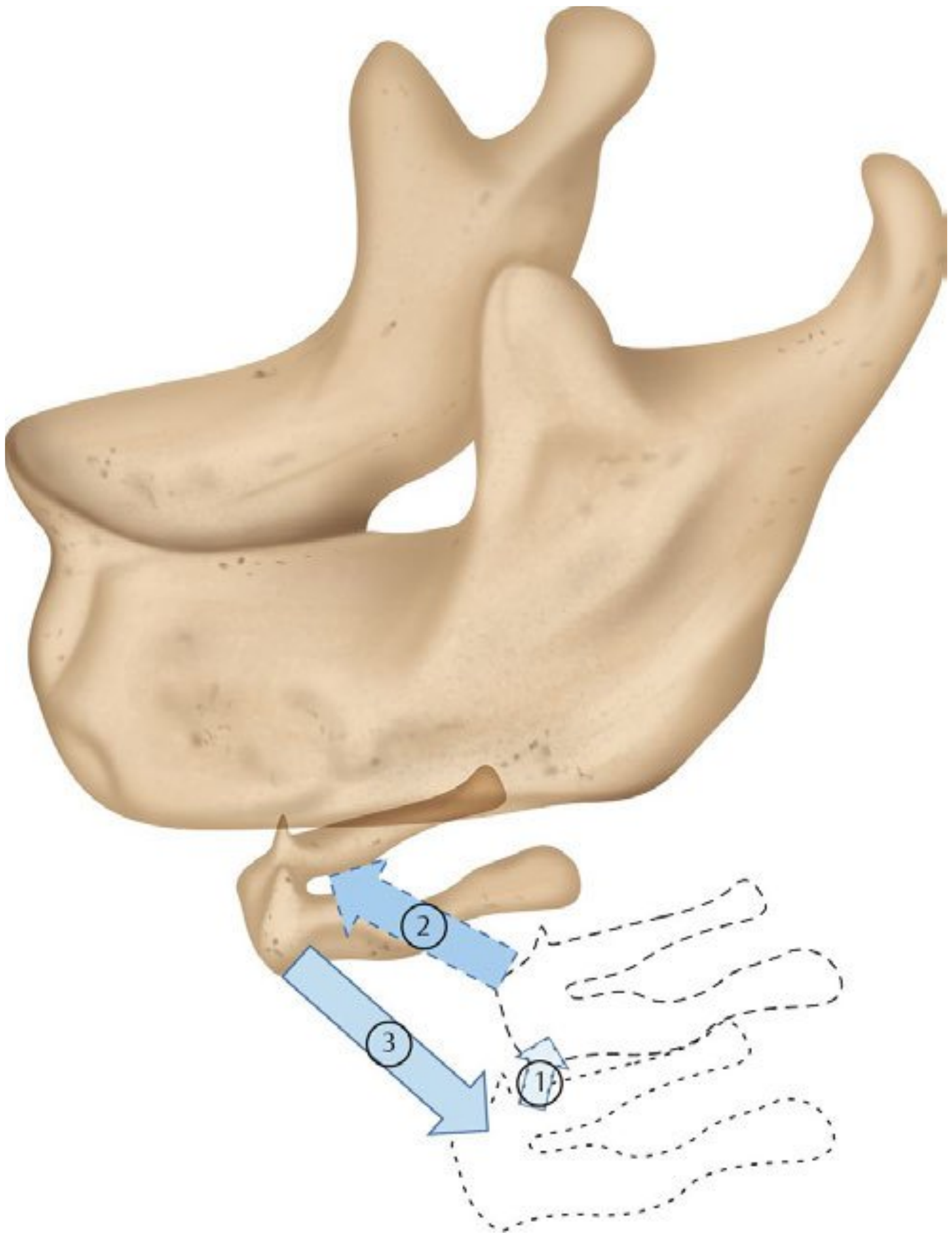


Fig. 20.18 Elevation patterns of the hyoid bone during swallowing 1. Moving backward; 2. moving forward; 3. to a lowered resting position.

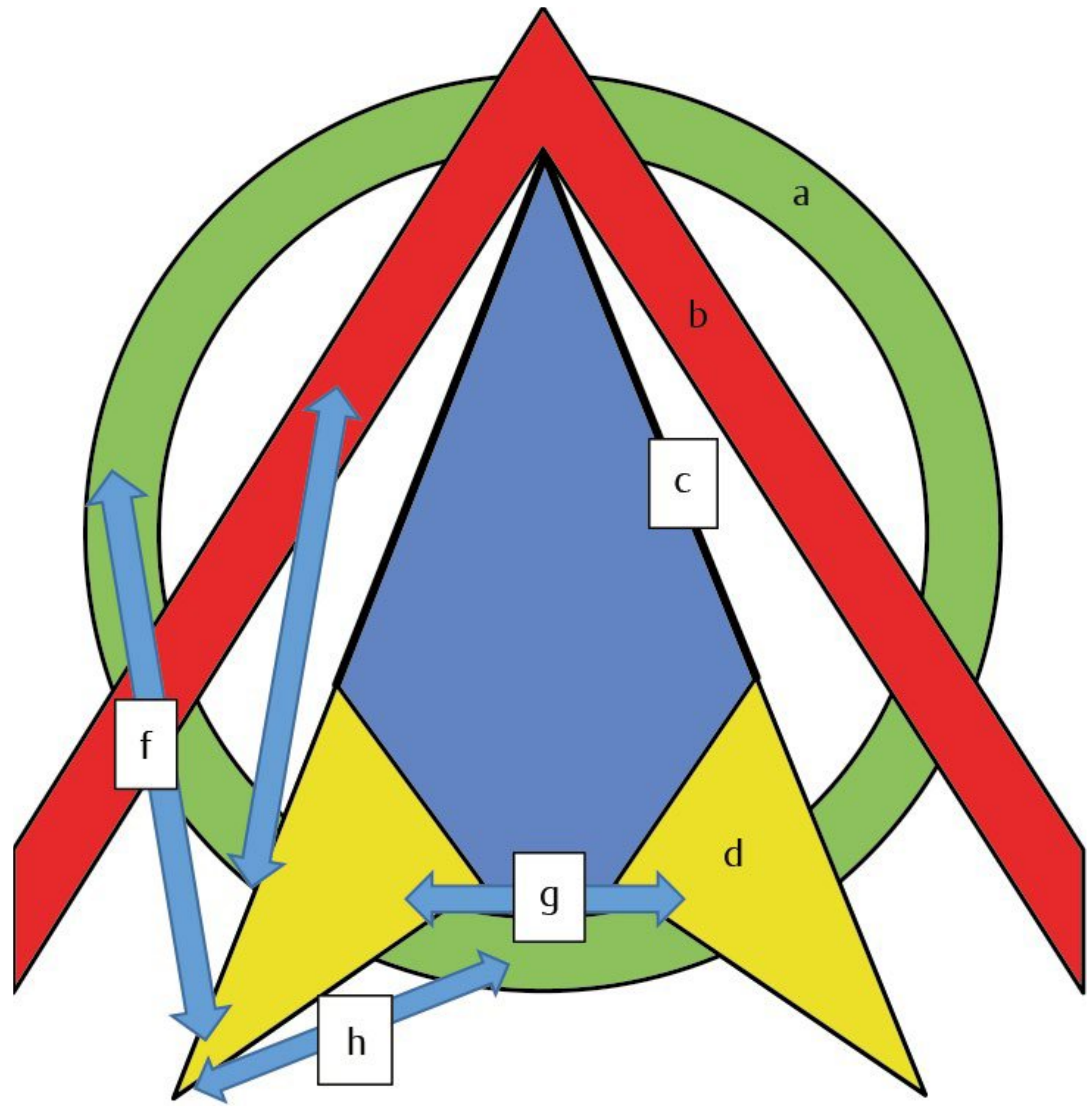


Fig. 20.19 Schematic diagram of laryngeal muscle actions. **(a)** Cricoid cartilage. **(b)** Thyroid cartilage. **(c)** Vocal cord membranous part. **(d)** Arytenoid cartilage. **(e)** Thyroarytenoid muscle. **(f)** Lateral cricoarytenoid muscle. **(g)** Interarytenoid muscles. **(h)** Posterior cricoarytenoid muscle.

known as the piriform recesses, which are in the form of an inverted cone. Their bases are closed by the contraction of the cricopharyngeus muscle, the sphincter muscle that forms the entrance to the esophagus. The cricopharyngeus muscle is part of the lower pharyngeal constrictor muscles; when the cricopharyngeus muscle relaxes and the larynx is elevated (moved forward), the esophageal entrance is opened, allowing the food bolus to pass through (**Fig. 20.14d**). Once the food bolus passes through the esophageal entrance, it is compressed by the larynx and the cervical vertebrae and passes, separately, to the left and right piriform recesses, avoiding the center.

End of the Pharyngeal Phase to the Esophageal Phase

When the food bolus is transferred to the esophagus, the soft palate, tongue, hyoid bone, and larynx return to their original positions (**Fig. 20.13f**). The glottis is opened wide and the cricopharyngeus muscle constricts, closing the entrance to the esophagus. The food bolus that has entered the esophagus is carried to the stomach by peristalsis, at a transfer speed of approximately 40 cm per second in the upper esophagus and 4 cm per second in the lower part, passing through the esophagus in around 10 seconds. In a healthy esophagus, peristalsis occurs after swallowing via a first contraction, occurring at the same time that the food bolus enters the upper esophagus, and a second contraction that occurs in response to the stimulation of the esophagus being widened by the food bolus.

Occlusion

Concepts about occlusion between the upper and lower teeth have changed over time; however, the theory relating to occlusion in the treatment of facial fractures is simple and unchanging. In this subchapter, we describe occlusion in relation to jaw fracture treatment. During surgery after facial trauma, the aim is to set the occlusion in the intercuspal position with the teeth in maximum intercuspation and then tighten the bones with screws. For simple fractures, it is easy to find the intercuspal position; however, in cases of complicated and multiple fractures, it is difficult for the surgeon to determine the correct occlusal position. One method for determining the intercuspal position is to look for occlusal facets in the upper and lower teeth. According to Schyler, these facets are present on the occlusal surfaces of the teeth as a result of functional or sometimes secondary movement of the mandible. This is regarded as a natural and inevitable process of occlusal equilibration. The facets also guide the mandible during the occlusal phase of mastication.[19]

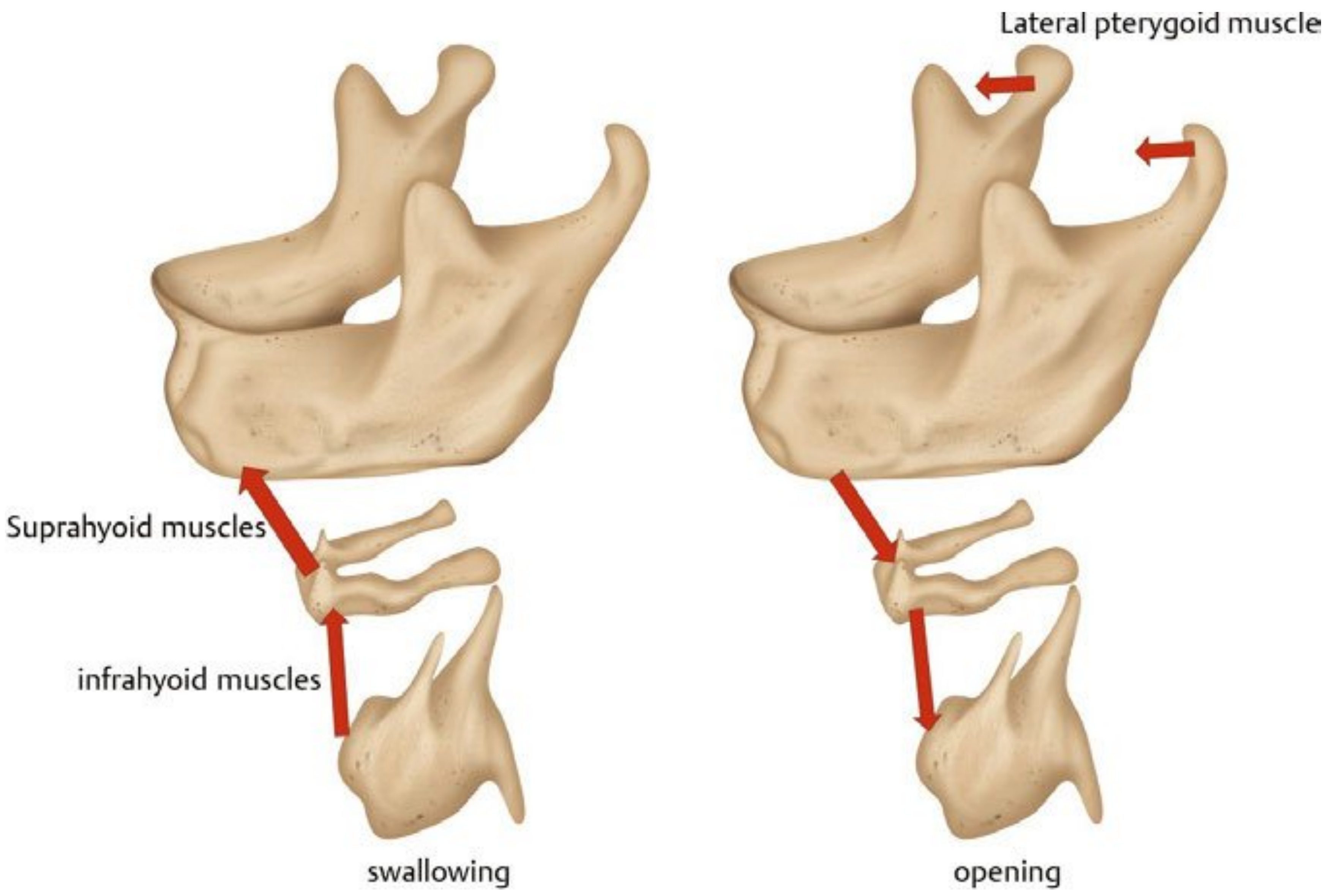


Fig. 20.20 Schematic diagram of the action of the muscles during swallowing and opening of the mouth.

Aesthetic Region

When considering the maxillofacial region as an aesthetic zone, we should think about many factors, such as face, eyes, lips, gingiva, and teeth.[20] In this section, we have made slight mention of the lips, gingiva, and teeth, which are closely related to the oral cavity. According to Lombardi, the facial midline is located at the center of the face and perpendicular to the interpupillary line.[21] Magne et al described the importance of the relationship between the edge of the incisor teeth and the lower lip line (**Fig. 20.21**). They also mentioned that the "golden proportion" and the "golden percentage," which apply to the apparent size of the teeth when viewed directly from the front (lateral incisor in a proportion of 1:1.618 to the central incisor and 1:0.618 to the canine) are too rigid for dentistry.[20] In 2012, Tsukiyama et al undertook a study comparing the morphology of the central incisor, lateral incisor, canine, and first premolar between white and Asian populations. They concluded that the central incisors of Asian subjects were narrower and more slender than those of white subjects (**Fig. 20.22**).[22] This study confirms that there is racial variation between white and Asian populations in terms of the morphology of the maxillary central incisor teeth and the facial skeleton. When thinking about the ideals of the aesthetic region, including the oral cavity, we should acknowledge the existence of different ideals among the races.

Fig. 20.21 Relationship between the edge of the incisor teeth and the lower lip line. (Picture provided by Dr. T. Tsukiyama with permission from Elsevier.)

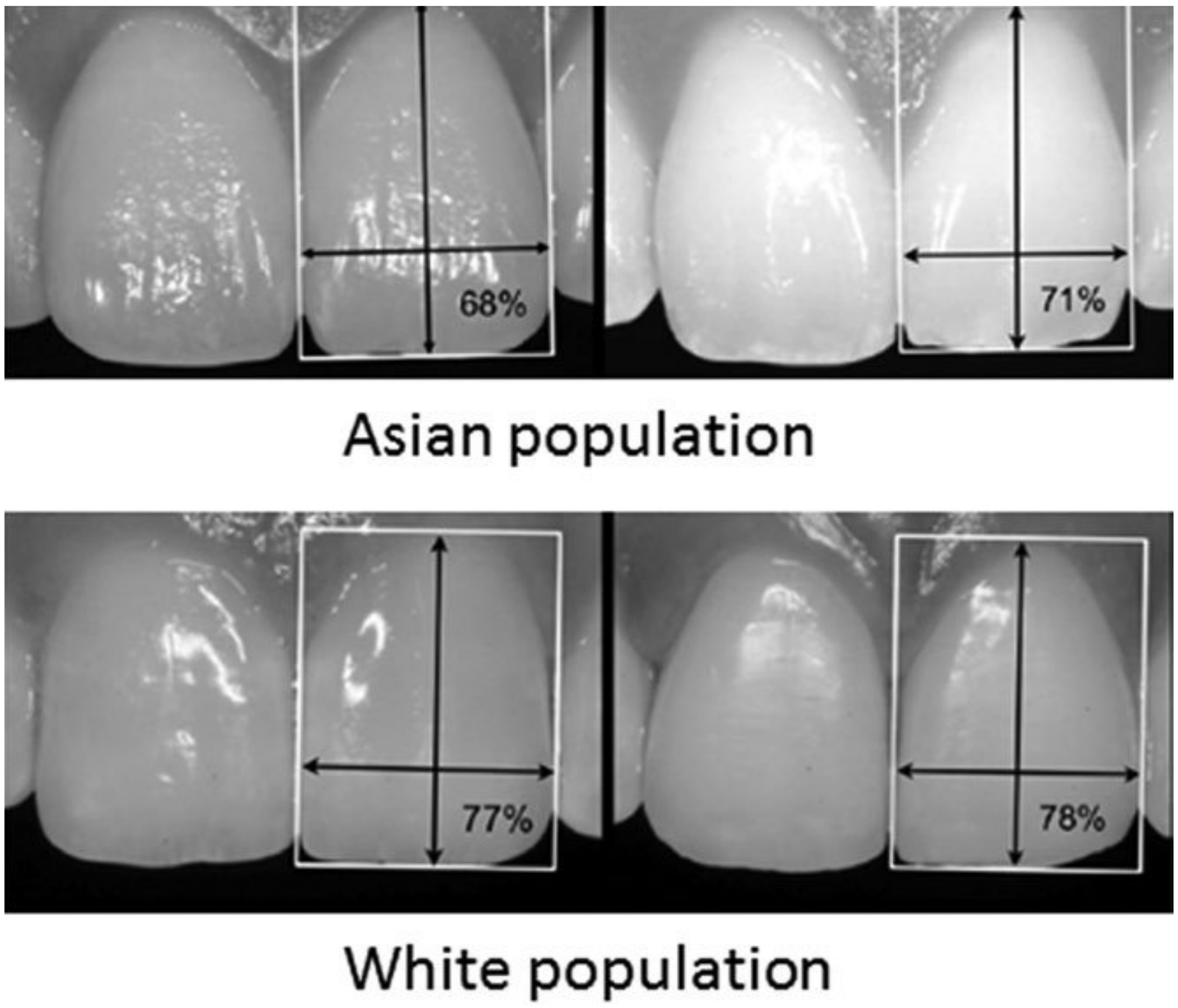


Fig. 20.22 Comparison of central incisors between Asian and white subjects. The numbers on the surface of the teeth show the width-to-length ratio of the central incisors (%). (Picture provided by Dr. T. Tsukiyama, with permission from Elsevier.)

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21 Neck

Sherine S. Raveendran and Lucian Ion

Introduction

The neck is a cylindrical structure that extends from the base of the skull to the thoracic inlet (**Fig. 21.1**). The neck encloses many vital structures and acts as a conduit between the cranium superiorly and the thorax and upper limb inferiorly. Anatomically, the neck is organized into three basic compartments:

- Posterior compartment: musculoskeletal (support and movement of the head and neck)
- Anterior compartment: visceral (glandular, respiratory, and gastrointestinal)
- Lateral compartment: large blood vessels and nerves

Skeletal Support

Cervical Spine

The cervical spine consists of seven vertebrae with some common characteristics and specific features for C1, C2, and C7 (**Fig. 21.2**). In the cervical region, the bodies of the vertebrae are relatively small, and wider transversely than anteroposteriorly, the pedicles are directed laterally and posteriorly, and the laminae are relatively narrow. The transverse processes are pierced by foramen transversaria, through which pass the vertebral artery from usually C1 to C6 vertebrae (**Fig. 21.3**).

The atlas (C1) is the uppermost of the vertebrae; it articulates with the base of the skull and allows anteroposterior movement. It does not have a vertebral body. The axis (C2) is the second vertebra and articulates with the atlas as a pivot that allows rotation. It has a characteristic odontoid process, rising perpendicular from the superior surface of the body. A strong transverse ligament completes the articulation between the atlas and the odontoid process posteriorly. C7 is known as the vertebra prominens and has a characteristic prominent spinous process that can be palpated; it represents the external landmark for the lower part of the cervical spine. In some individuals, C7 is associated with an abnormal extra rib (cervical rib), which can produce symptoms of compression of blood vessels at the root of the neck or of the brachial plexus. When symptomatic, it is referred to as thoracic outlet syndrome.

Surgical Annotation

In a number of genetic syndromes, including Down's syndrome, after infections of the spine and in patients with a history of rheumatoid arthritis, the atlantoaxial joint can be unstable, and in hyperextension, it leads to compression of the spine, which may be fatal. Patients who have a history of rheumatoid or predisposing genetic syndromes are at greater risk for a general anesthetic as a result of the need to hyperextend the neck during intubation.

Hyoid Bone

The hyoid takes support only from the muscles and ligaments associated with mobility of the gastroesophageal and respiratory visceral structures in the neck and floor of mouth (**Fig. 21.4**). The bone has a U-shape contour and is divided into three components: the body, positioned anterior and horizontally, and laterally paired projections, the greater and lesser horns or cornua. The greater horns project posteriorly and superiorly, and the lesser horns project superiorly. The hyoid bone provides attachment to muscles that move the tongue, depresses the mandible, and moves the larynx. The superior attachments are for the middle pharyngeal constrictor, hyoglossus, mylohyoid, geniohyoid, stylohyoid, and digastric muscles. The inferior attachments are for the thyrohyoid, stylohyoid, and omohyoid muscles.

Skin, Adipose Tissue, Fascia

Skin

The skin on the neck is thin and drapes along the contour of the deeper structures anteriorly. The skin on the posterior neck has thicker dermis, with stronger stabilizing fibrous septae, and has limited mobility. In the submental and submandibular areas, the skin is less adherent. In the postauricular and mastoid regions, it is closely attached to the underlying tissues.

Adipose Tissue

The adipose tissue in the neck is distributed in the supraplatysmal, interplatysmal, and subplatysmal planes (**Fig. 21.5**). The anatomical studies reveal that the fat in the subcutaneous plane ranges from 8.4 to 15 g (**Fig. 21.5a**). The total amount of fat in this region can vary in the presence of weight excess. The fat in the subplatysmal plane averages 3.7 g (**Fig. 21.5b**). In clinical settings, it appears to be less influenced by weight variations. The fat is compartmentalized in the submental region.[1–3]

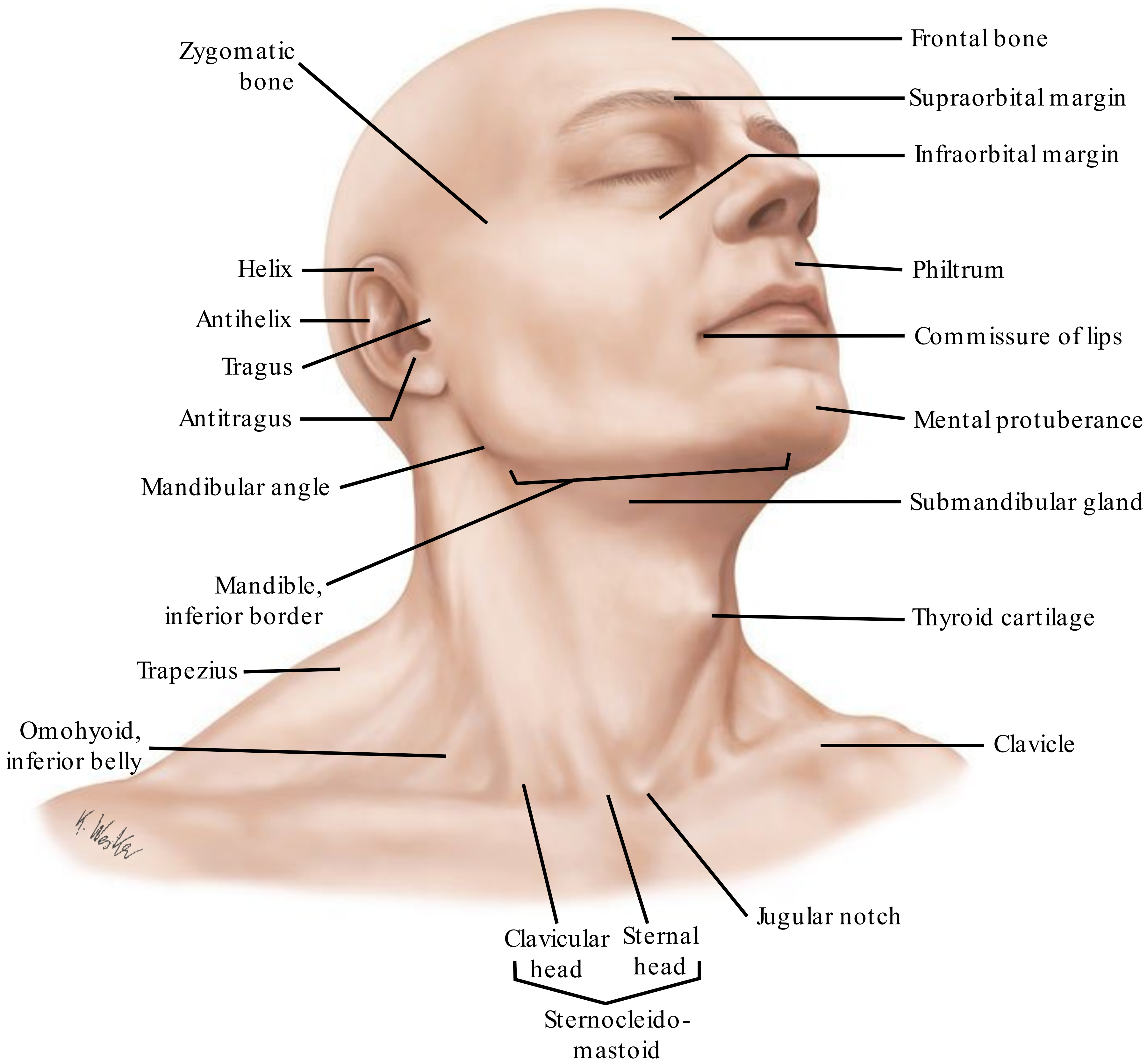
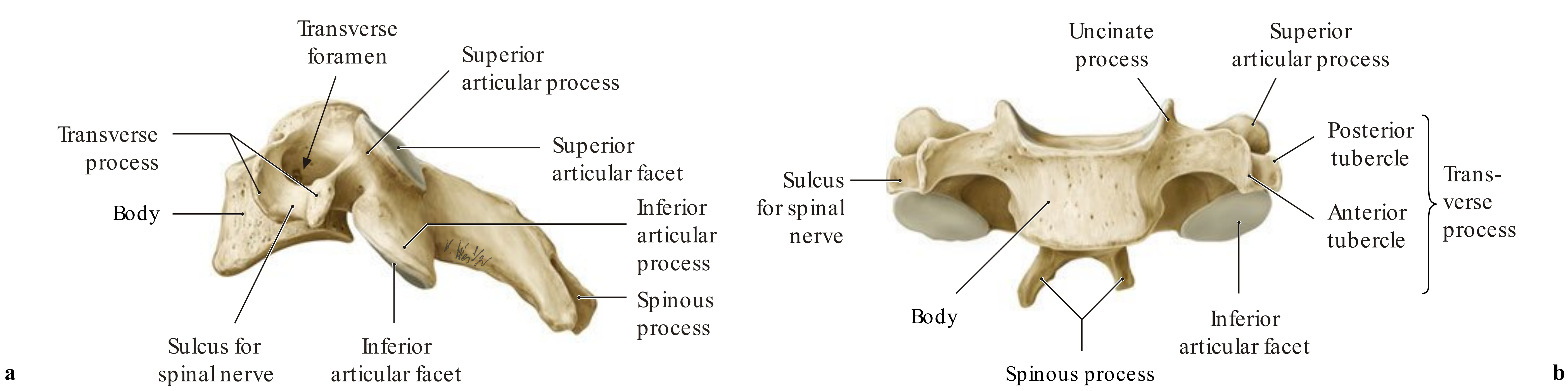


Fig. 21.1 Surface anatomy and external landmarks of the neck. (From THIEME Atlas of Anatomy, General Anatomy and Musculoskeltal System. © Thieme 2005, Illustration by Karl Wesker.)



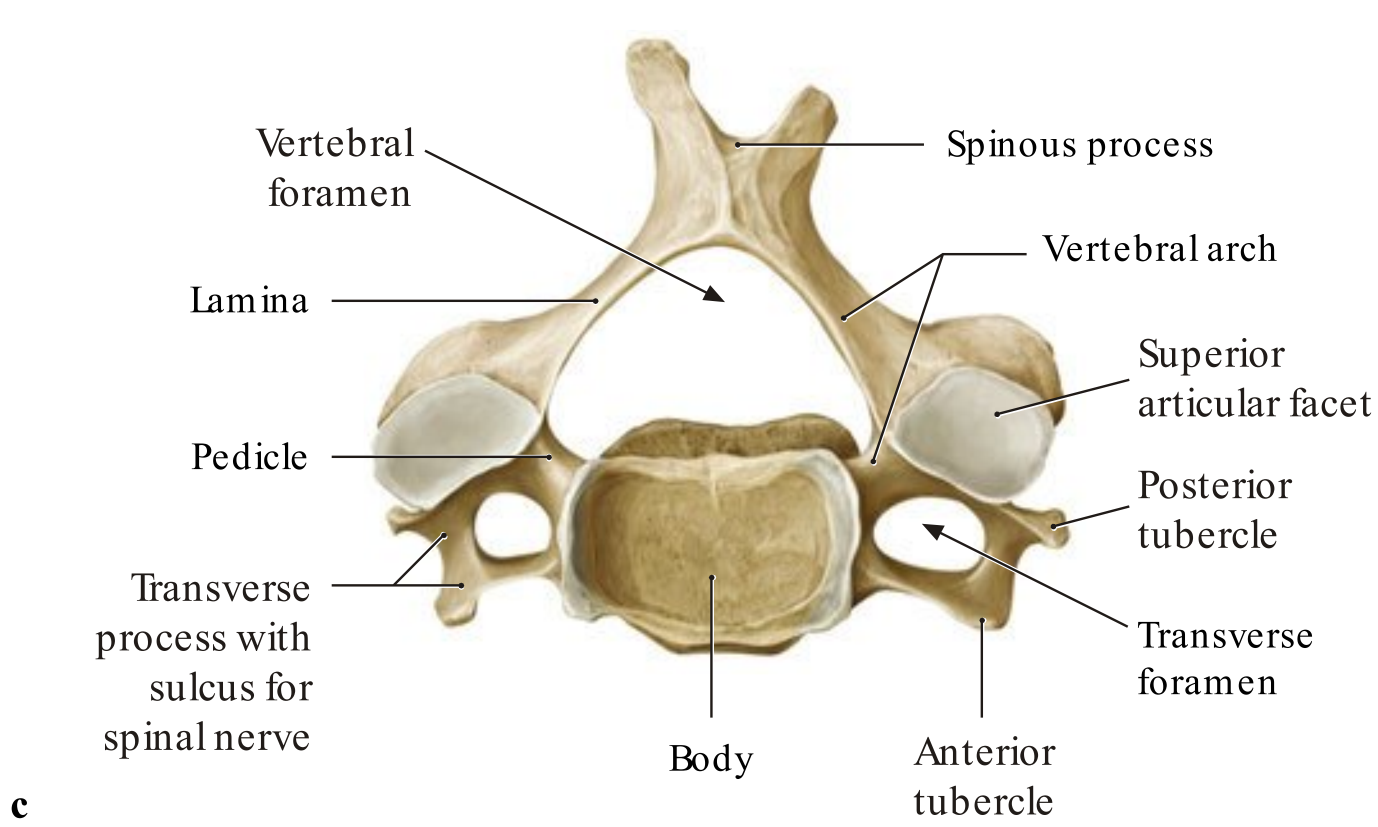


Fig. 21.2 Typical cervical vertebra (C4). **(a)** Left lateral view. **(b)** Anterior view. **(c)** Superior view. (From THIEME Atlas of Anatomy, General Anatomy and Musculoskeltal System. © Thieme 2005, Illustrations by Karl Wesker.)

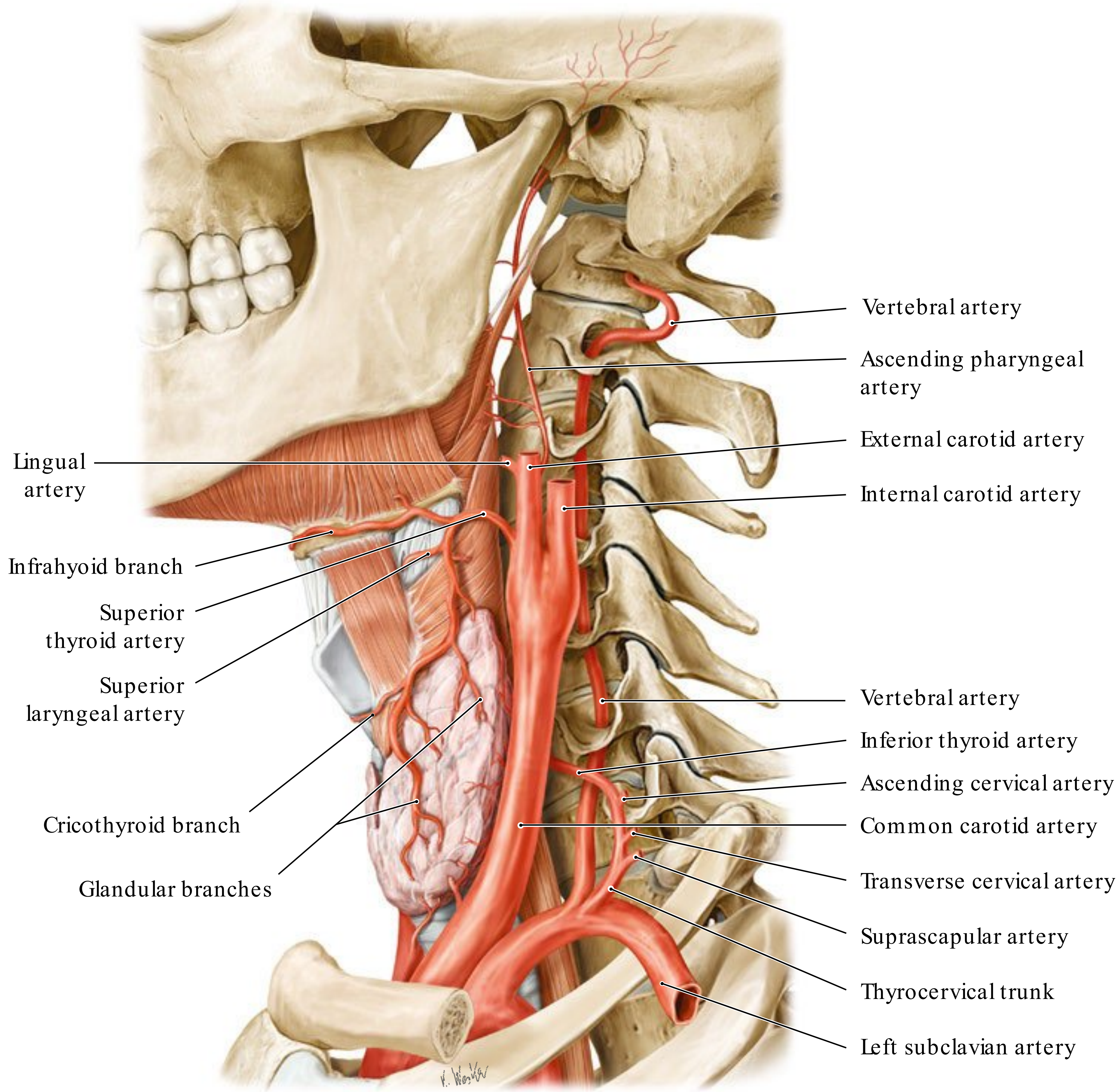


Fig. 21.3 Passage of the vertebral artery through the foramen transversarium of the cervical vertebra. (From THIEME Atlas of Anatomy, General Anatomy and Musculoskeltal System. © Thieme 2005, Illustration by Karl Wesker.)

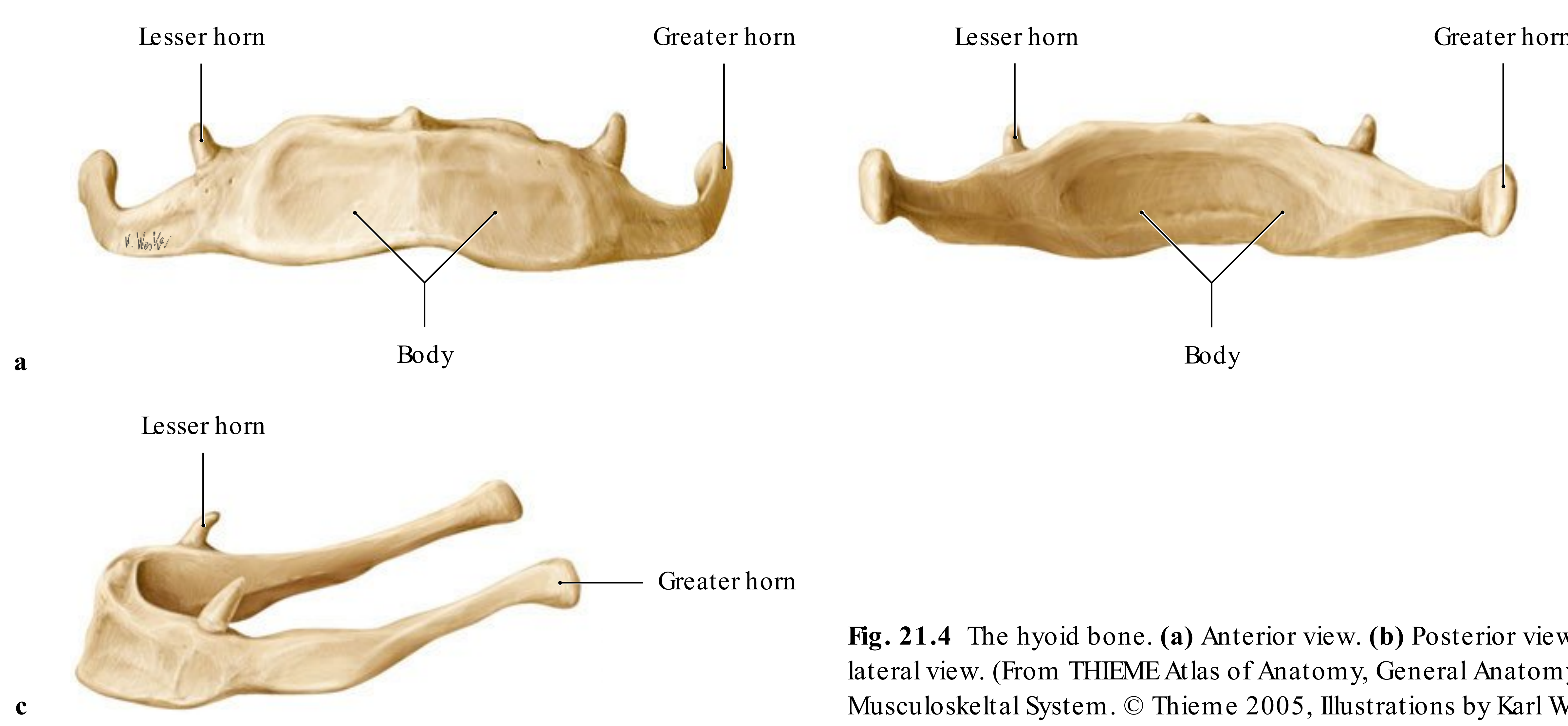


Fig. 21.4 The hyoid bone. **(a)** Anterior view. **(b)** Posterior view. **(c)** Left lateral view. (From THIEME Atlas of Anatomy, General Anatomy and Musculoskeltal System. © Thieme 2005, Illustrations by Karl Wesker.)

a

b

Fig. 21.5 Adipose tissue distribution in the superficial and deep planes of the neck **(a)** superficial fat and **(b)** deep fat.

Surgical Annotation

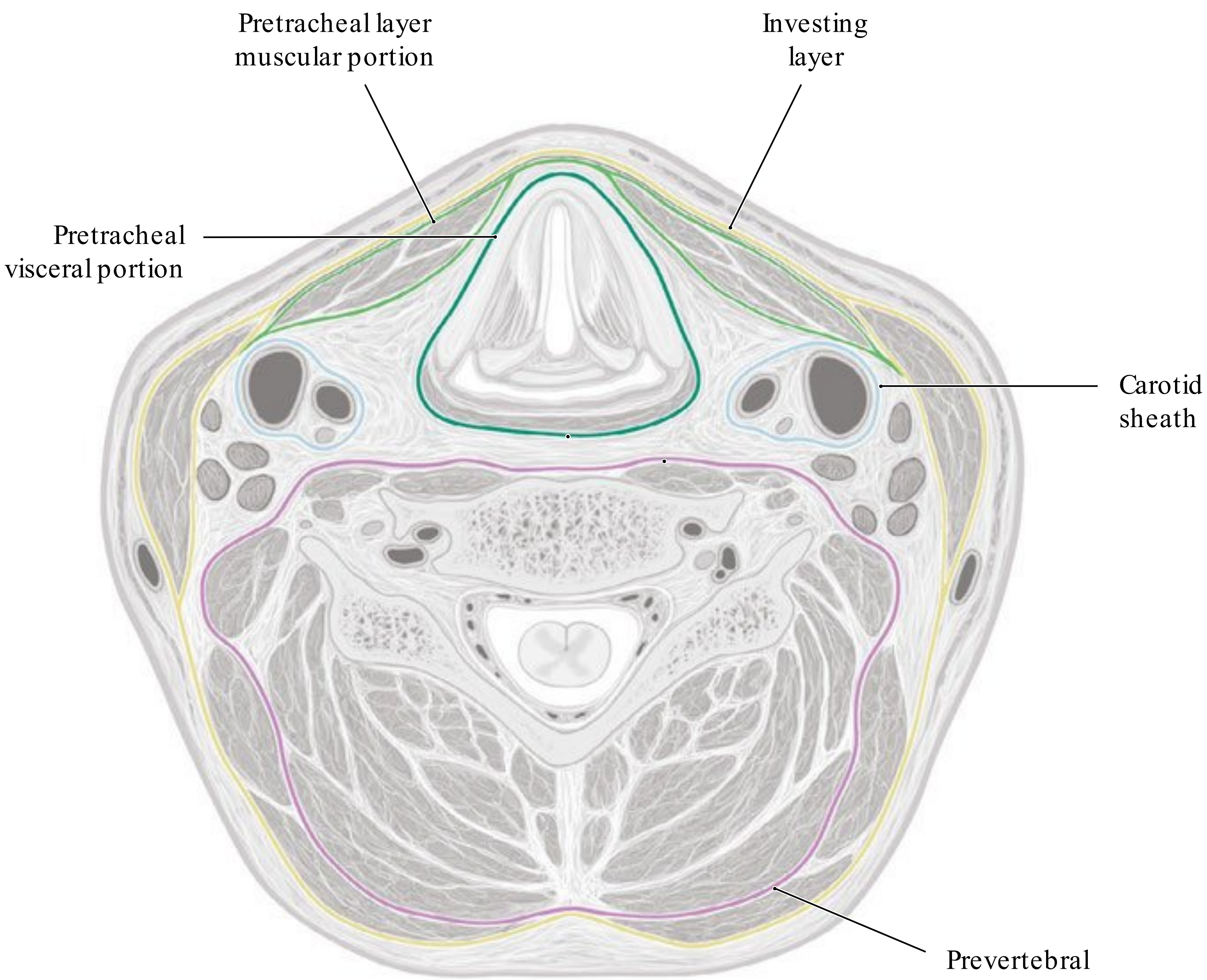
The volume of the neck is determined by the extent of fat deposition, which in turn determines the girth of the neck. In the fatty neck, there is fat deposition in the superficial and the deeper layers, generating a less defined or even convex shape of the cervicomental angle. Volume reduction during neck contouring can incorporate volume reduction in all fat compartments of the anterior neck to reduce girth and to improve contours. In slim necks, there is minimal fat and the skin drapes over the platysma causing visible bands in older subjects.

Cervical Fascia

The cervical fascia is broadly divided into superficial and deep layers (**Fig. 21.6**).

Superficial Cervical Fascia

Superficial cervical fascia is the continuation of the superficial musculoaponeurotic system (SMAS), also referred to as the SMAS layer. It contains cutaneous nerves, blood vessels, lymphatics, and variable amounts of fat. The platysma is found



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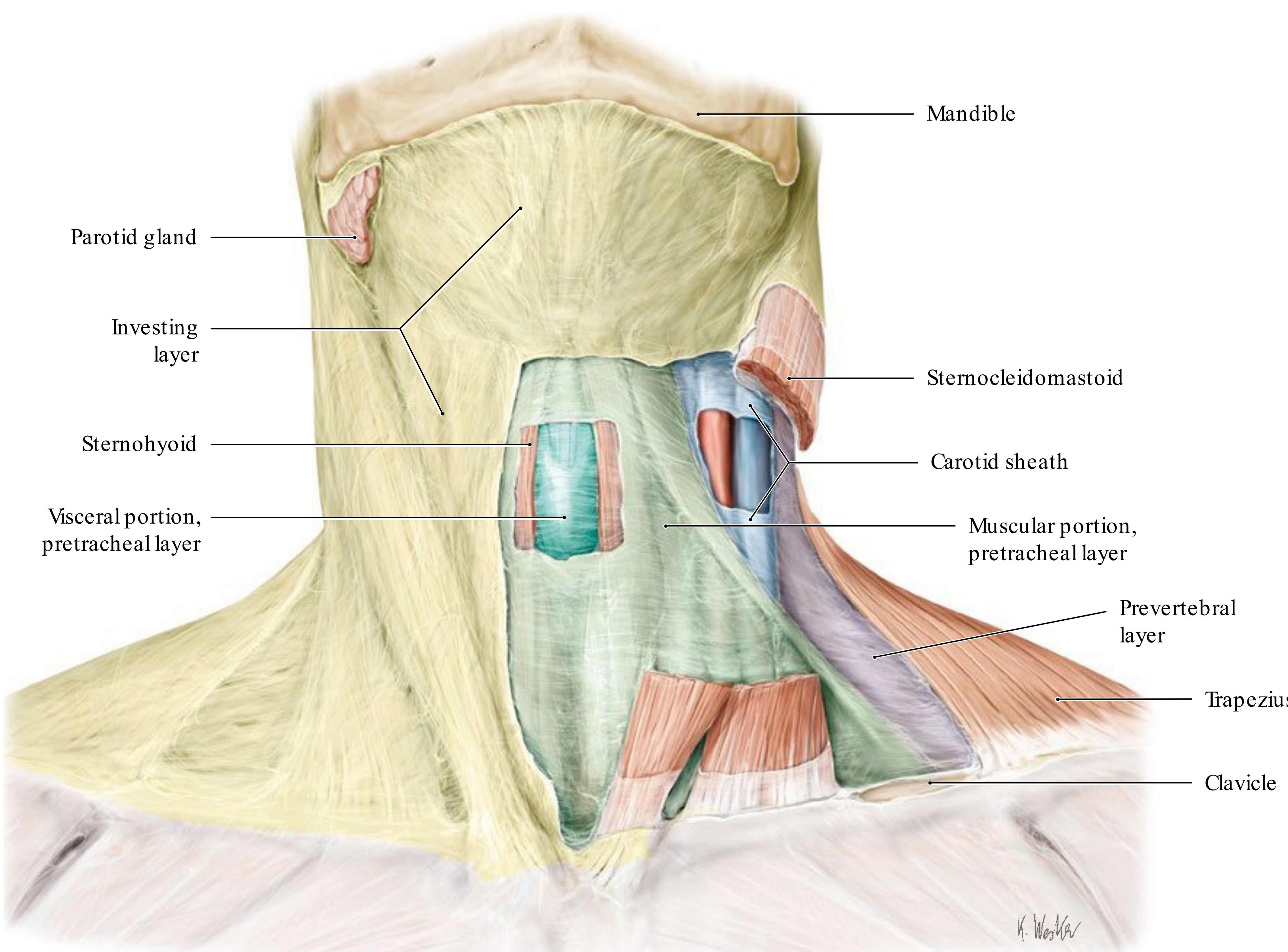

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Fig. 21.6 Cervical fascia layers. **(a)** Transverse section of the neck. **(b)** Anterior view with skin, superficial fascia, and platysma removed. (From THIEME Atlas of Anatomy, General Anatomy and Musculoskeltal System. © Thieme 2005, Illustrations **(a)** by Markus Voll and **(b)** by Karl Wesker.)

anterolaterally and is adherent to the skin via multiple connective tissues bands. It is a paired muscle found lateral to the midline.

Platysma

The platysma muscle is a thin, wide superficial muscle, originating from the superficial fascia over the upper thorax (**Fig. 21.7a**). The muscle fibers fan out superiorly and inserted into the lower border of the mandible and skin and intermingle with the muscles of facial expression on the lower face. Its innervation is provided by the cervical branch of the facial nerve, and the blood supply is provided by the facial artery, superior thyroid artery, and branches of the posterior auricular and occipital arteries. Its main action in humans is as an accessory depressor of the oral commissure. The platysma muscle courses over the concave contours of the neck and does not have any retention ligaments or pulleys superficial to it. Its deep attachments, the cervical retaining ligaments, adherent to the superficial layer of the deep fascia, are responsible limiting the anterior displacement of the muscle belly during contraction. Later in life, the muscle is responsible for the appearance of vertical dynamic bands, labelled as platysma bands.

Surgical Annotation

The platysma is classified into three types, depending on the extent of decussation[4]:

- Type 1: Limited decussation of the platysma muscles, extending 1 to 2 cm below the mandibular symphysis (75%)
- Type 2: Decussation of the platysma from the mandibular symphysis to the thyroid cartilage (15%)
- Type 3: No decussation of the platysma muscles in the midline (10%)

Isolated platysmal bands associated with ageing can be successfully treated with neurotoxins. Correction of extensive laxity and divarication requires open procedures with interventions on the platysma muscles; plication, excision, and myotomy, and so forth.[5–7] The superiorly and posteriorly based platysma muscle myocutaneous flaps are supplied primarily by the submental artery and secondarily by the superior thyroid, postauricular, and occipital arteries. The external jugular and submental veins provide the venous drainage. The platysma skin flap can be used to reconstruct defects in the orofacial region.[8,9]

Deep Cervical Fascia

The deep fascia can be divided into three layers: the investing layer of the deep cervical fascia, prevertebral fascia, and pretracheal fascia.

Investing Layer of the Deep Cervical Fascia

The investing layer completely encircles the neck and splits to enclose the trapezius and sternocleidomastoid muscles. The investing layer of the deep cervical fascia is attached superiorly to the external occipital protuberance and superior nuchal line and inferiorly to the sternum, clavicle, and acromion of the scapula. The posterior attachments are on the spines of the cervical vertebrae and ligamentum nuchae, and the anterior attachments are on the mandibular midline, body of the hyoid, and manubrium sterni. The fascia splits to enclose the suprasternal space and the attachments of the trapezius and sternocleidomastoid muscles.

In the mastoid region, the investing layer of the fascia is referred to as the parotid fascia, which splits into two layers to enclose the parotid gland. The parotid fascia is attached to the tip of the mastoid process, cartilaginous part of the external acoustic meatus, and lower border of the zygomatic arch. The deep layer extends along the base of the skull and merges with the carotid sheath. The fascia between the styloid process and the angle of the mandible forms the stylomandibular ligament.

Pretracheal Fascia

The pretracheal fascia extends from the hyoid to the thorax. The visceral layer envelops the trachea, esophagus, and thyroid gland and the muscular part encloses the infrathyroid muscles.

It is attached superiorly to the larynx, and inferiorly it extends along the superior mediastinum and merges with the fibrous pericardium.

Prevertebral Fascia

The prevetebral fascia encloses the cervical spine and the prevetebral and postvertebral muscles. It also forms the floor of the posterior triangle of the neck. The fascia extends superiorly to the skull base in front of the longus capitis and rectus capitis lateralis muscles and inferiorly into the thorax, where it merges with the anterior longitudinal ligament of the third thoracic vertebra. The fascia inserts posteriorly on the transverse and spinous processes of the cervical vertebrae and ligamentum nuchae. Inferiorly, the fascia covers the scalene muscles and extends laterally as axillary sheath.

Carotid Sheath

The carotid sheath receives contributions from prevetebral and pretracheal fasciae. It encloses the carotid artery, vagus nerve, lymph nodes, and internal jugular vein. The attachments of the carotid sheath are superiorly to the skull base, and inferiorly the fascia merges with the connective tissue surrounding the aortic arch.

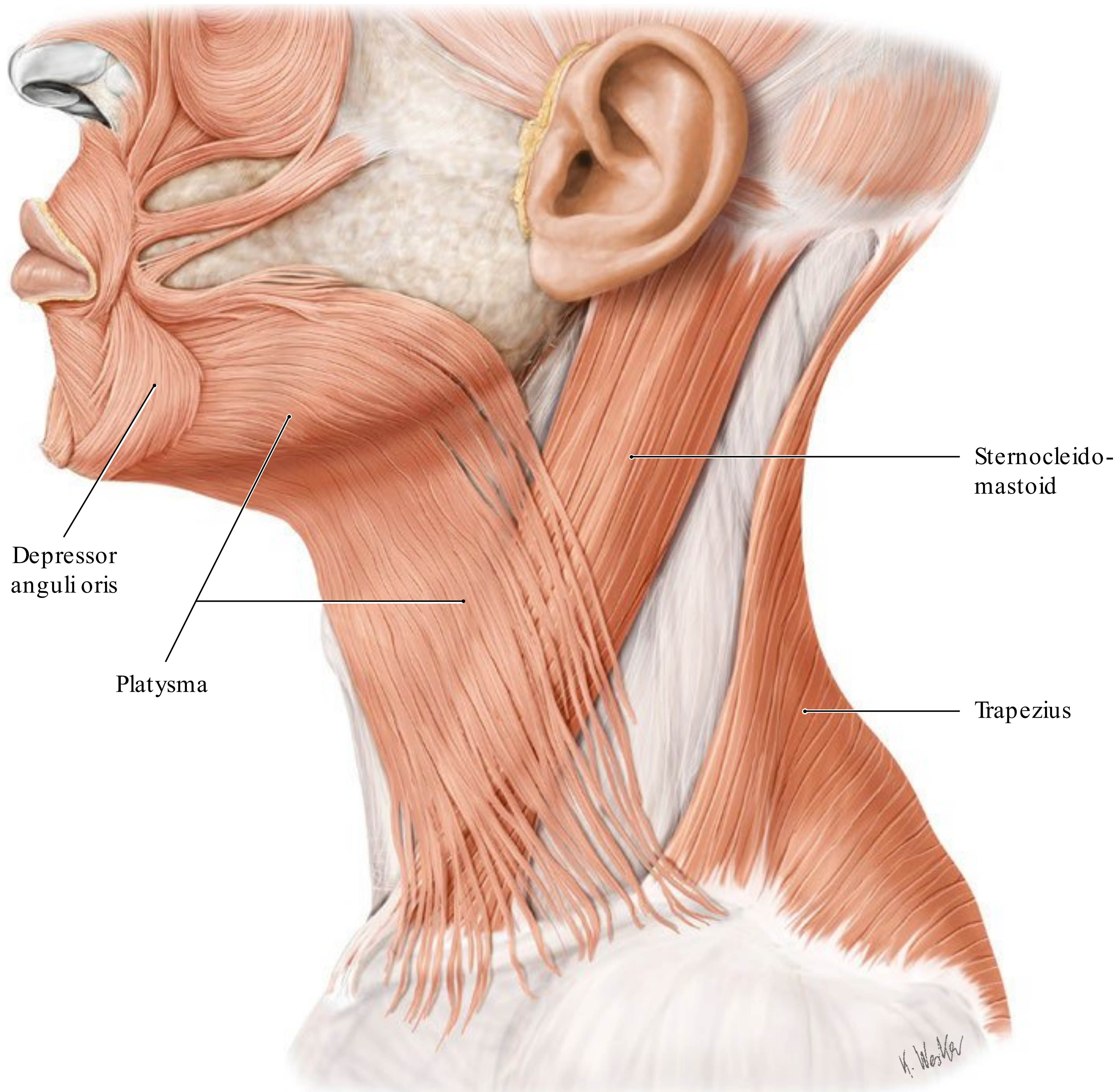
Attachments

- Superior: Base of the skull
- Inferior: The fascia merges with the connective tissue around the arch of the aorta

Surgical Annotation

The arrangements of the fascial layers of the neck determine the spread of infection in the neck. They form important barriers to infection; once infection is established, the fascial layers play a part in directing its spread. The infection may travel through paths of least resistance from one space to another. The investing layer limits the spread of superficial infection. Deeper infections can spread to the thorax and retropharyngeal spaces.[10,11]

Fig. 21.7 Neck muscles. **(a)** The platysma muscle. **(b)** The superficial and middle layers of the muscle in the neck.



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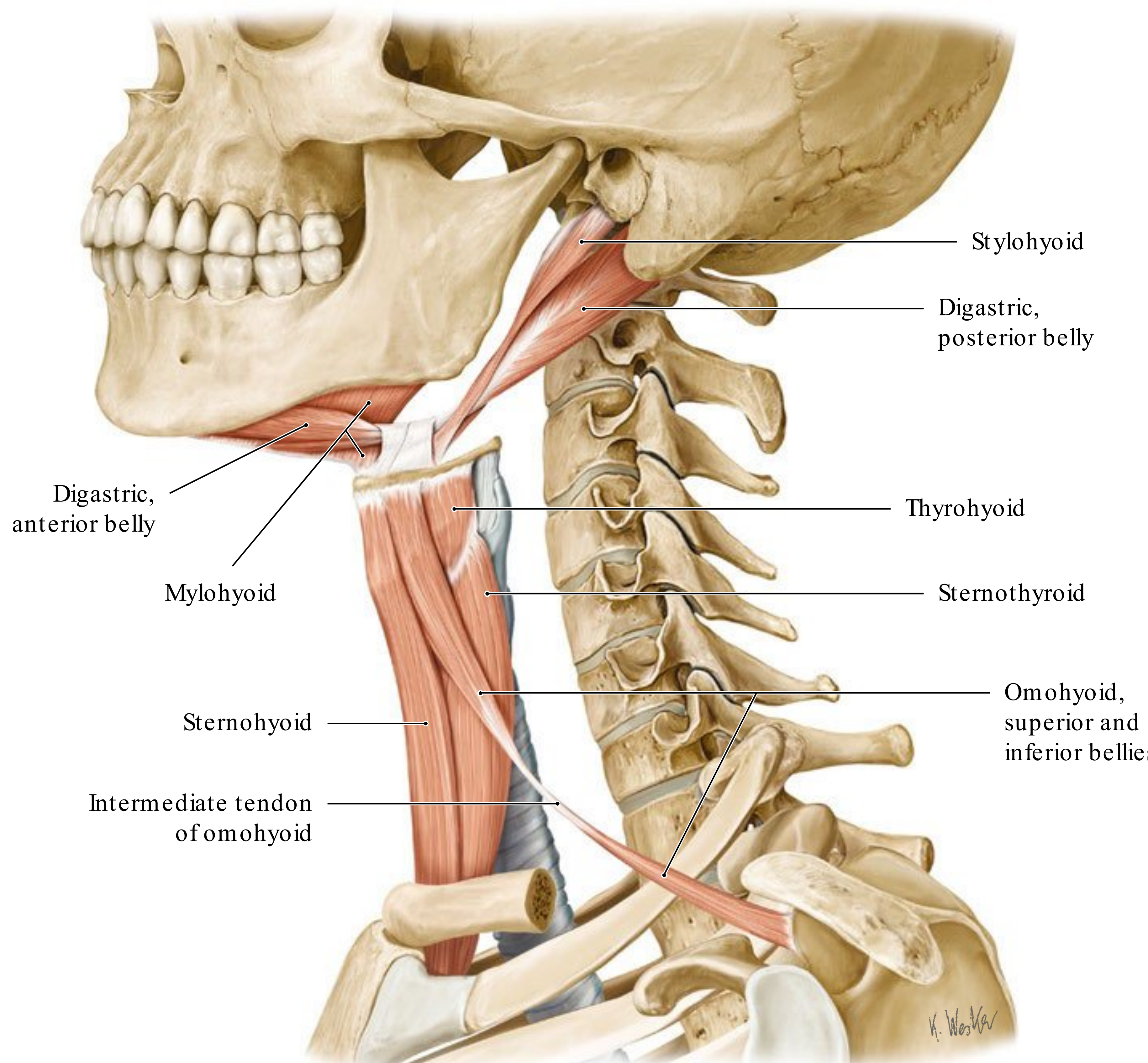

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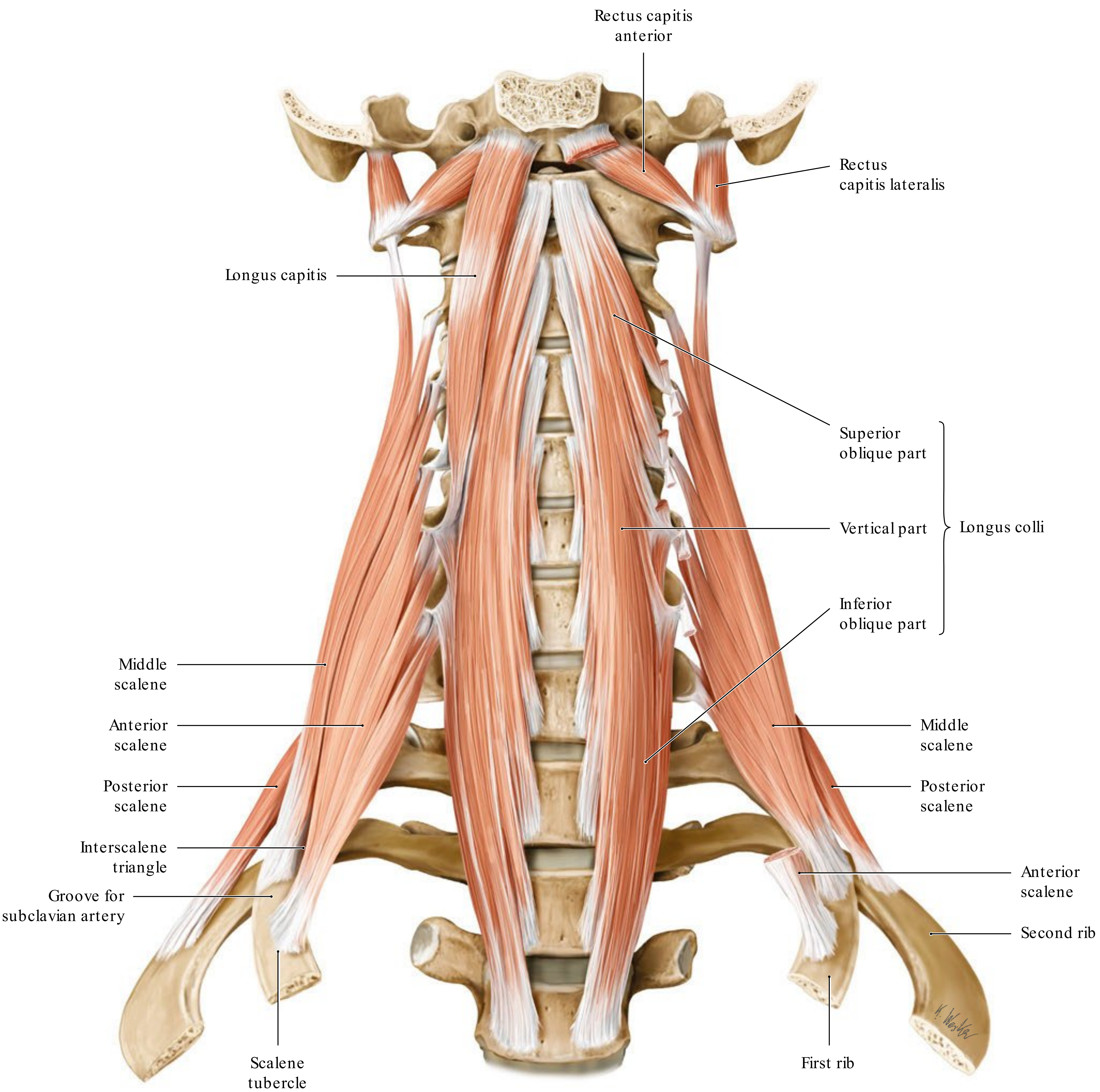

Fig. 21.7 (continued) **(c)** The deep muscle layers of the neck. (From THIEME Atlas of Anatomy, General Anatomy and Musculoskeltal System. ©Thieme 2005, Illustrations by Karl Wesker.)

Muscular Anatomy

Lateral Compartment

Sternocleidomastoid

This muscle is an important landmark of the neck as it defines the triangles of the neck and is closely related to the deeper neurovascular structures (**Fig. 21.7b**):

- Origin: It arises from two heads, tendinous (sternal) head from the manubrium sterni and muscular (clavicular) head from the upper surface of the medial third of the clavicle.
- Insertion: The muscle passes upward and outward and is inserted onto the mastoid process and the superior nuchal line.
- Blood supply: The blood supply is through the superior thyroid, occipital, posterior auricular, and suprascapular arteries.
- Nerve supply: The spinal accessory nerve is the nerve supply.

- Action: When one muscle contracts, the head is tipped toward the shoulder on the same side to rotate the face to the opposite side. When acting together, the head is moved forward.

The muscle is sacrificed in radical neck dissection along with other structures of the neck.

Surgical Annotation

In congenital unilateral hypoplasia of the sternocleidomastoid muscle, the muscle belly is shortened and tight, leading to a condition called torticollis. If left untreated, it leads to progressive mandibular and facial asymmetry through the growth period.

Anterior Compartment

Strap Muscles of the Neck

- Superficial layer: Omohyoid, sternohyoid
- Deep layer: Sternothyroid, thyrohyoid
- Nerve supply: Ansa cervicalis, thyrohyoid by the first cervical nerve
- Blood supply: Superior thyroid and lingual arteries

The omohyoid has superior and inferior bellies that are joined by an intermediate tendon. The superior belly is attached to the hyoid bone, and the inferior belly is attached to the scapula. The intermediate tendon is attached to the clavicle and first rib. The omohyoid depresses the hyoid bone from the elevated position. The sternohyoid and sternothyroid muscles originate from the posterior surface of the manubrium sterni. Sternohyoid has additional attachment on the clavicle and is inserted into the inferior border of the body of the hyoid bone. The sternothyroid is attached to the oblique line of the thyroid cartilage. The thyrohyoid muscle arises from the oblique line of the thyroid cartilage and is attached to the body and grater horn of the hyoid. The strap muscles act on the hyoid bone and larynx and assist in swallowing. The digastric, stylohyoid, mylohyoid, geniohyoid, hyoglossus, and genioglossus are classified together as muscles of the floor of the mouth.

Digastric Muscle

The digastric muscle consists of two bellies: the anterior belly and the posterior belly. Both bellies are connected by an intermediate tendon anchored to the hyoid.

Posterior Belly

- Origin: The mastoid notch is posterior to the mastoid process.
- The posterior belly of the digastric muscle runs forward and downward and passes through the stylohyoid muscle.
- Insertion: Insertion is to the greater horn of the hyoid bone by a fibrous loop.
- Blood supply: The blood supply is through the posterior auricular and occipital arteries.
- Nerve supply: The posterior belly is supplied by the facial nerve.

Anterior Belly

- Origin: The digastric fossa on the inferior border of the mandible is the origin.
- Insertion: The muscle runs downward and backward and is connected to the posterior belly via the intermediate tendon.
- Blood supply: Blood supply is through the submental branch of the fascial artery.
- Nerve supply: The mandibular division of the trigeminal nerve provides the nerve supply.
- Action: The digastric muscle helps to raise the hyoid bone and base of the tongue and assists in depressing and retracting the mandible.

Surgical Annotation

Excision of the anterior belly of digastric muscles is carried out as part of some neck dissections, as well as during some cosmetic interventions on the neck. The hypoglossal nerve courses deep to the anterior belly of the digastric muscle and mylohyoid muscles, transversely over the hypoglossus, and needs to be protected during surgery. Blunt dissection with hemostat clamps can be used to elevate the muscle belly from the underlying structures, and once the hypoglossal nerve has been visualized, superior and inferior transection of the muscle belly can be carried out safely.

Posterior Compartment

Posterior Neck Muscles: Trapezius

- Origin: External occipital protuberance, superior nuchal line, ligamentum nuchae, and the spine of the seventh cervical vertebra and spines of the all the thoracic vertebrae.
- Insertion: Spine and acromion of the scapula, lateral third of the clavicle
- Nerve supply: Accessory nerve, cervical plexus
- Blood supply: Superficial cervical, transverse cervical arteries
- Action: Elevates, rotates, and retracts the scapula with other muscles. When scapula is fixed, the trapezius moves the head backward and lateral.

Surgical Annotation

The trapezius myocutaneous flap is used for most of the head and neck reconstruction. It is classified as type V in the Mathes and Nahai classification and can be used as pedicled-islanded flap, free flap, and turnover flap. The flap is a popular choice for reconstruction of the defects over the occipital, parotid gland, cervical spine, and anterior neck. The superior fibers are designed mainly for head and neck reconstruction, but the arc of rotation is limited; however, it is possible to use the middle and inferior fibers of the trapezius for myocutaneous flaps.[12,13]

Paravertebral Muscles

The paravertebral muscles are located in front of the bodies of the cervical vertebrae, deep to the prevertebral fascia (**Fig. 21.7c**). The muscles are longus colli, longus capitis, rectus capitis anterior and lateralis, scalene muscles, and the levator scapulae.

- Blood supply: Vertebral arteries, ascending pharyngeal, and inferior thyroid arteries
- Nerve supply: Cervical spinal nerves
- Action: Scalene muscles are flexors and rotators of the vertebral column. The scalenus anterior and medius elevate the first rib and scalenus posterior elevates the second rib.

Postvertebral Muscles

The post vertebral muscles lie deep to the trapezius, behind the vertebral column, and are arranged in three layers: superficial layer (splenius cervicis and capitis muscles); middle layer (the erector spinae muscles); and deep layer (transversospinalis muscles). When acting on both sides of the splenius capitis, they cause extension of the head. The splenius cervicis is involved in the extension of the cervical spine. When acting on one side, they cause tilting of the head with slight rotation to one side.

Peripheral Nerves of the Neck

The ventral and dorsal rami of the second and third cervical nerves innervate the anterior and posterior skin of the neck, respectively.

Cervical Plexus

The cervical plexus is formed from the ventral rami of the first cervical nerves (C1–C4) and also receives anastomoses from the accessory nerve, hypoglossal nerve, and sympathetic trunk. Its cutaneous branches emerge from the posterior border of the sternocleidomastoid approximately midpoint along the muscle; the motor divisions remain posterior to the sternocleidomastoid. The cutaneous branches of the cervical plexus include the lesser occipital nerve, greater auricular nerve, and the supraclavicular nerves (**Fig 21.8**). The motor branches are the ansa cervicalis and the segmental branches to the anterior and middle scalene nerves (**Fig 21.9**). The phrenic nerve arises from the cervical plexus and has both the sensory and motor components.

The dorsal rami of the first, sixth, seventh, and eighth cervical nerves have no cutaneous branches. The ansa cervicalis is part of cervical plexus, which mainly innervates the infrahyoid muscles. The brachial plexus is derived from the ventral rami of the cervical spinal nerves and lies deep in the posterior triangle of the neck. The cervical sympathetic trunk lies behind the carotid sheath on the prevertebral fascia. The main cutaneous branches of the cervical plexus are the lesser occipital, the great auricular, the transverse cervical, and the supraclavicular nerves. The lesser occipital nerve arises from the ventral ramus of the second and third cervical nerves and supplies the lateral part of the scalp. The greater occipital nerve is a branch of dorsal ramus of the second cervical nerve. This nerve is found in the suboccipital triangle; it pierces the trapezius and supplies the posterior scalp. The transverse cervical nerve arises from the second and third cervical nerves and passes across the sternocleidomastoid muscle to supply the skin on the anterior neck. The supraclavicular nerve receives fibers from the third and fourth cervical nerves. The nerve runs downward toward the clavicle and divides into three branches. These are the medial, intermediate, and lateral supraclavicular nerves, and they supply the skin over the lower neck and upper thorax.

The great auricular nerve arises from the second and third nerves of the cervical plexus and travels from a deep to superficial plane. The nerve reaches the posterior border of the sternocleidomastoid muscle at the junction of the superior and middle thirds of the muscle.[14]

Surgical Annotation

The surface landmark of the great auricular nerve is referred to as the nerve point, located 6.5 cm inferior to the external auditory meatus. The nerve takes an oblique path toward the earlobe following the course of the external jugular vein. The vein lies about 0.5 cm medial to the nerve. Because the nerve is covered only by the SMAS superiorly, this layer should be identified to protect the nerve during dissection. Damage to the nerve leads to numbness of the lower two-thirds of the ear, preauricular skin, and postauricular skin and may result in neuroma formation.

The phrenic nerves arise from C3, C4, and C5 and descend over the anterior scalene muscle deep to the prevertebral fascia.

Cranial Nerves in the Neck

The cranial nerves in the neck are anatomically related to the carotid sheath. The vagus nerve runs within the carotid sheath, and the glossopharyngeal, accessory, and hypoglossal nerves are closely related to these structures.

The glossopharyngeal nerve exits the skull through the jugular foramen. The superior and inferior ganglia are found within the foramen. The nerve is found anterior to the vagus and accessory nerves and runs between the internal jugular vein and carotid artery. It winds around the stylopharyngeus muscle and passes between the superior and middle constrictors. The main branches include the tympanic, lesser petrosal, carotid, pharyngeal, tonsillar, lingual, and a branch to the stylopharyngeus muscle.

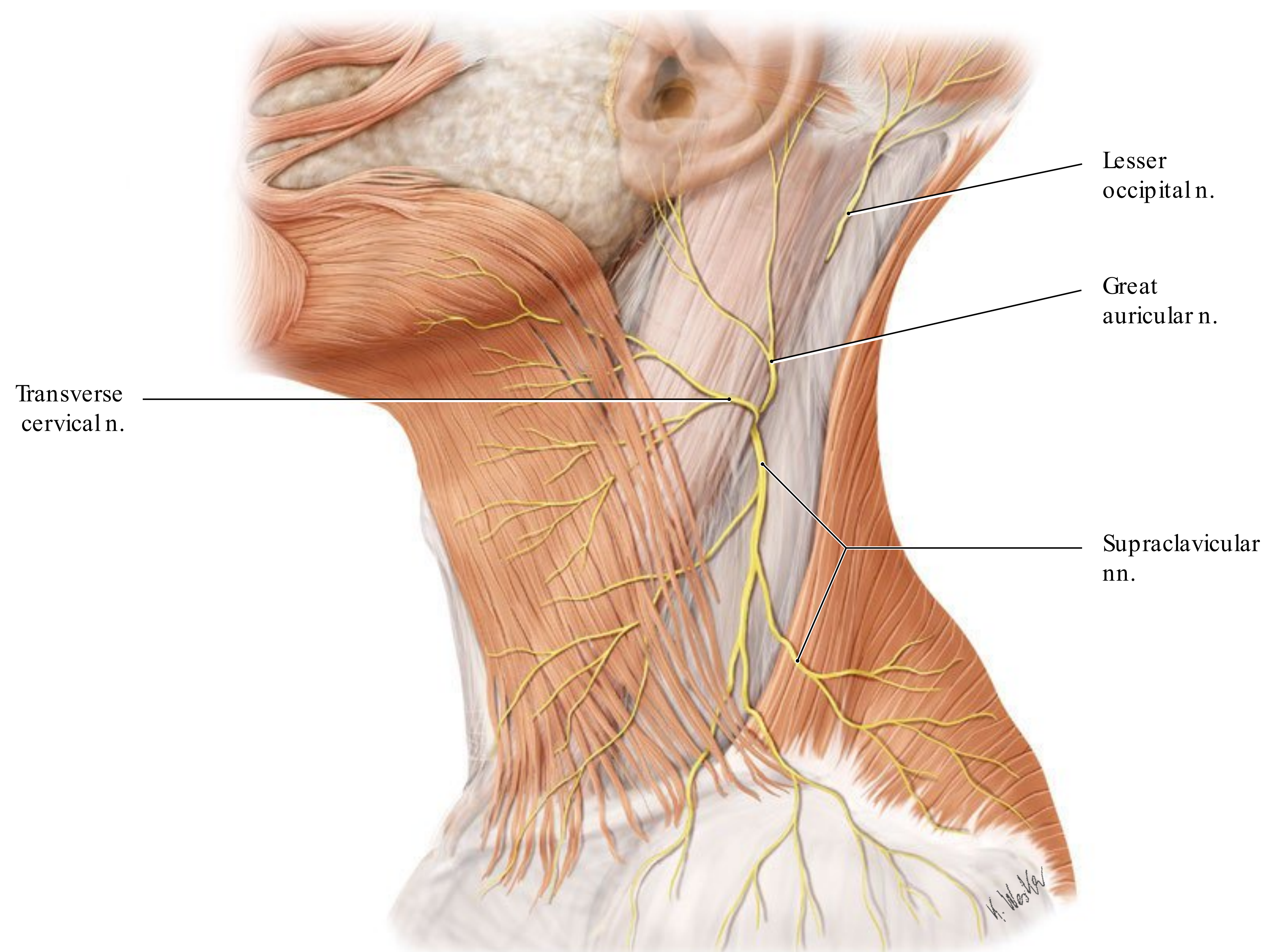

Fig. 21.8 Cutaneous branches of the cervical plexus. (From THIEME Atlas of Anatomy, General Anatomy and Musculoskeltal System. © Thieme 2005, Illustration by Karl Wesker.)

The accessory nerve has cranial and spinal parts. The cranial part joins the vagus nerve. The spinal part of the nerve is derived from the upper five cervical segments. The main trunk passes through the foramen magnum, crosses the internal jugular vein, and runs downward toward the sternocleidomastoid muscle and supplies the muscle. It then crosses the posterior triangle and supplies the trapezius muscle. The spinal and cranial parts of the accessory nerves unite in the jugular foramen and soon separate as they emerge through the cranium.

The vagus nerve exits the jugular foramen and is joined by the cranial part of the accessory nerve. The nerve passes within the carotid sheath and gives rise to the right recurrent laryngeal

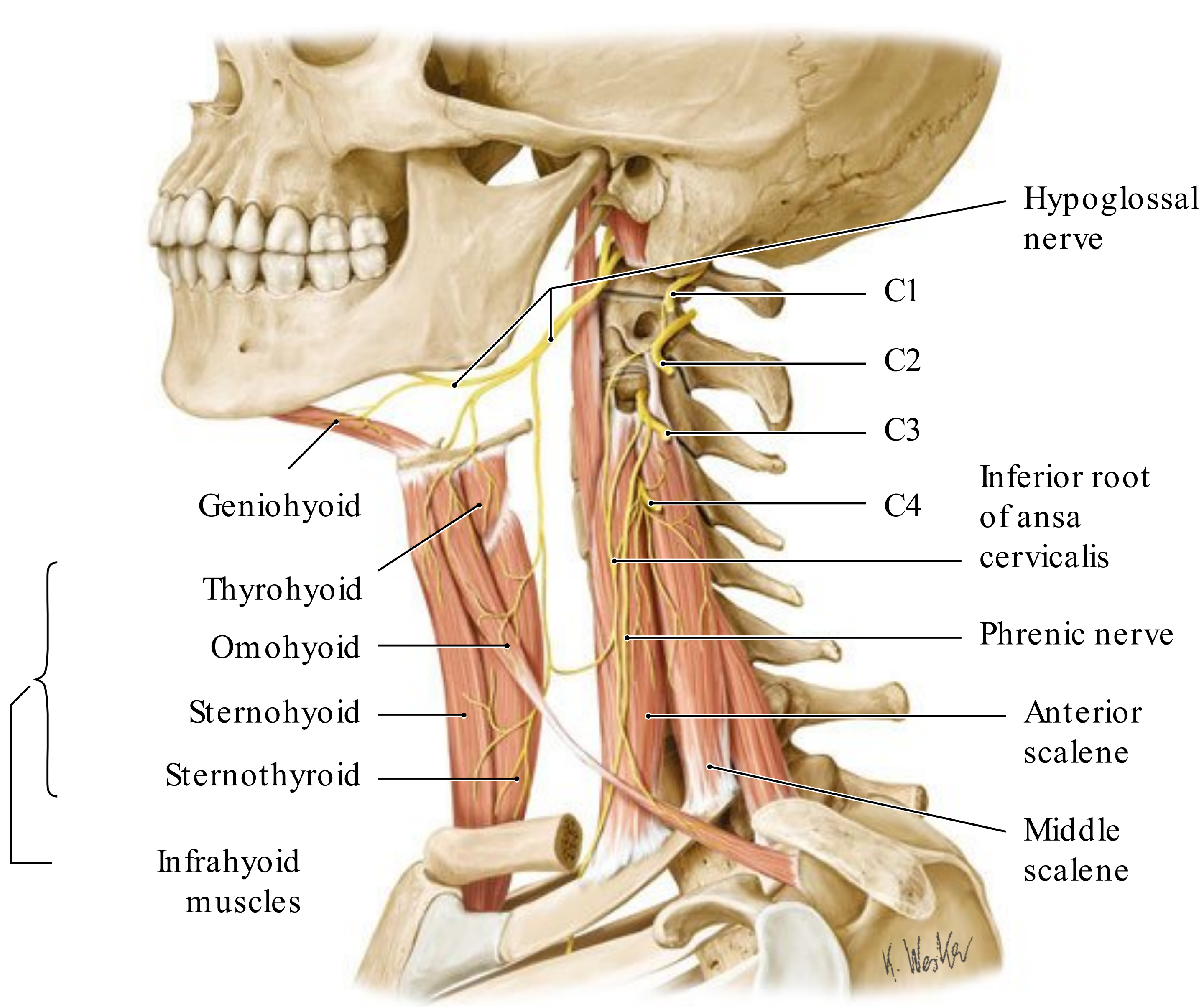

Fig. 21.9 The motor innervations of the neck muscles. (From THIEME Atlas of Anatomy, General Anatomy and Musculoskeltal System. © Thieme 2005, Illustration by Karl Wesker.)

nerve in the root of the neck. The left recurrent laryngeal nerve arises in the thorax, and both nerves course upwards between the trachea and esophagus. The other branches of the vagus nerve include the meningeal, auricular, pharyngeal, carotid body, superior laryngeal, and cardiac nerves.

Surgical Annotation

The nerves that are closely related to the carotid sheath can be damaged during neck dissection. The accessory nerve emerges at the posterior border of the sternocleidomastoid and takes a posterior and inferior course toward the trapezius muscle. It runs superficially, under the cervical fascia, and can be easily injured during neck dissection. Dissection in the posterior region of the posterior border of the sternocleidomastoid needs to take into account the superficial position of the nerve. At this point, the nerve emerges approximately at the midportion of the sternocleidomastoid and courses posteriorly. The accessory nerve is removed in radical neck clearance and is preserved in modified radical dissections. Removal of this nerve causes weakness and chronic shoulder pain.[15,16]

Facial Nerve Branches in the Neck

The marginal mandibular nerve is a branch of facial nerve and is one of the most common nerves to be damaged during neck surgery (**Fig. 21.10**). The nerve follows the mandibular border anteriorly and lies 2 cm below the inferior border before crossing the facial artery and vein. It supplies the depressor labii inferioris, depressor anguli oris, and the mentalis muscles (**Fig. 21.11**).

Surgical Annotation

The nerve is vulnerable during liposuction, neck lift, neck dissection, and mandibular implant placement. Surgical techniques, such as staying deep to the superficial cervical fascia and elevation of the deep fascia with the periosteum of the mandible, will help to protect the nerve.[17]

The cervical branch of the facial nerve innervates the platysma muscle and enters the deeper surface of the muscle superolaterally. Damage to this nerve is reported at 1.7% during rhytidectomy.[18] Injury to this nerve can mimic marginal mandibular nerve damage; however, the patient will still be able to evert the lower lip due to an intact mentalis muscle. In the lower face, the facial nerve runs deep to the platysma and SMAS and innervates the muscles on their under surfaces except for the buccinator, levator anguli oris, and mentalis muscles.

Surgical Annotation

Identification of the facial nerve during parotidectomy can be carried out in the neck. Dissection starts with the posterior border of the platysma approximately 5 cm below the gonial angle and extends inferiorly and superiorly. The parotid fascia and parotid gland are exposed, and the dissection can progress to the anterior border of the gland for a retrograde identification of the facial nerve branches and dissection or to the posterior border of the gland for identification of the nerve trunk with an antegrade

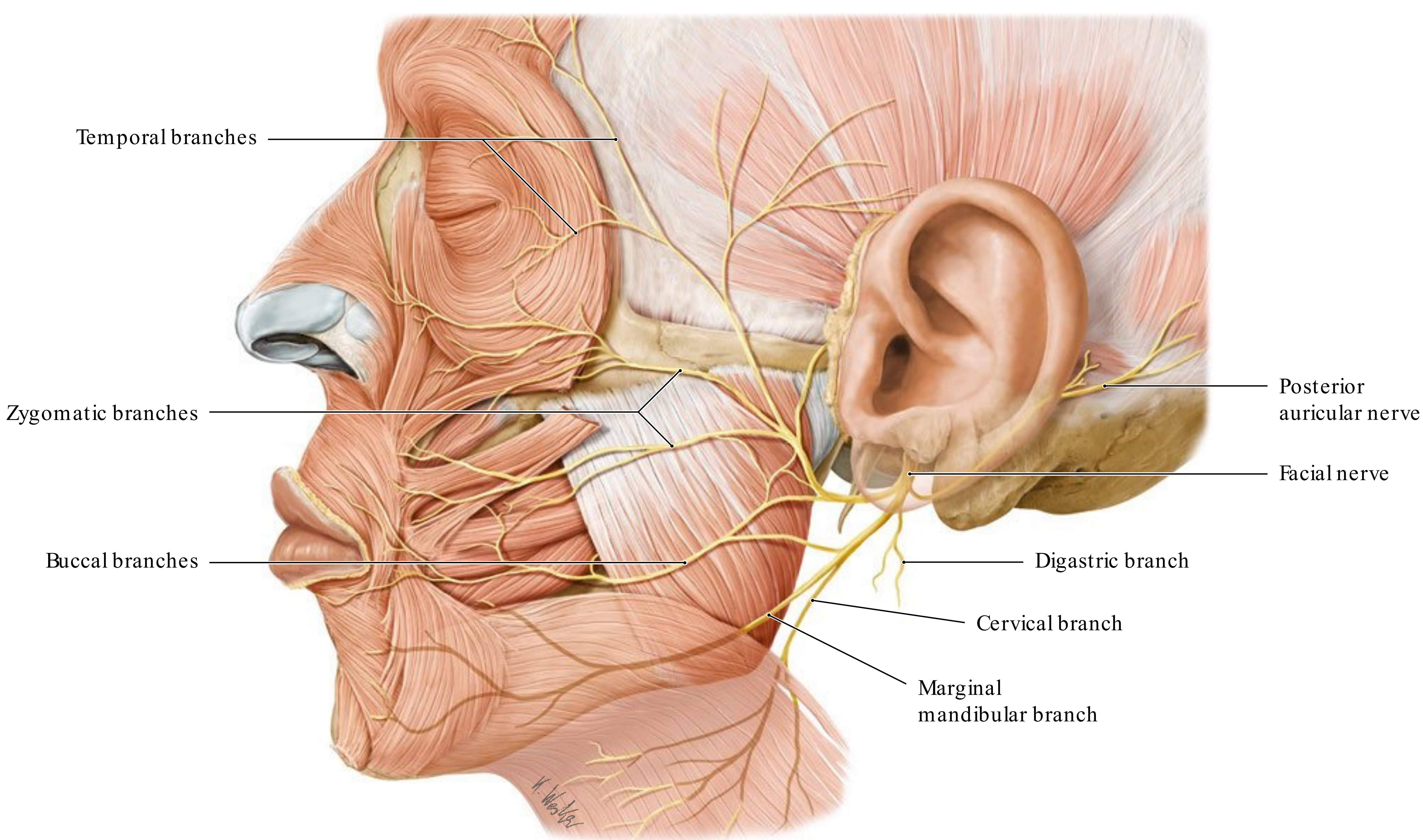

Fig. 21.10 Branches of facial nerve. (From THIEME Atlas of Anatomy, General Anatomy and Musculoskeltal System. © Thieme 2005, Illustration by Karl Wesker.)

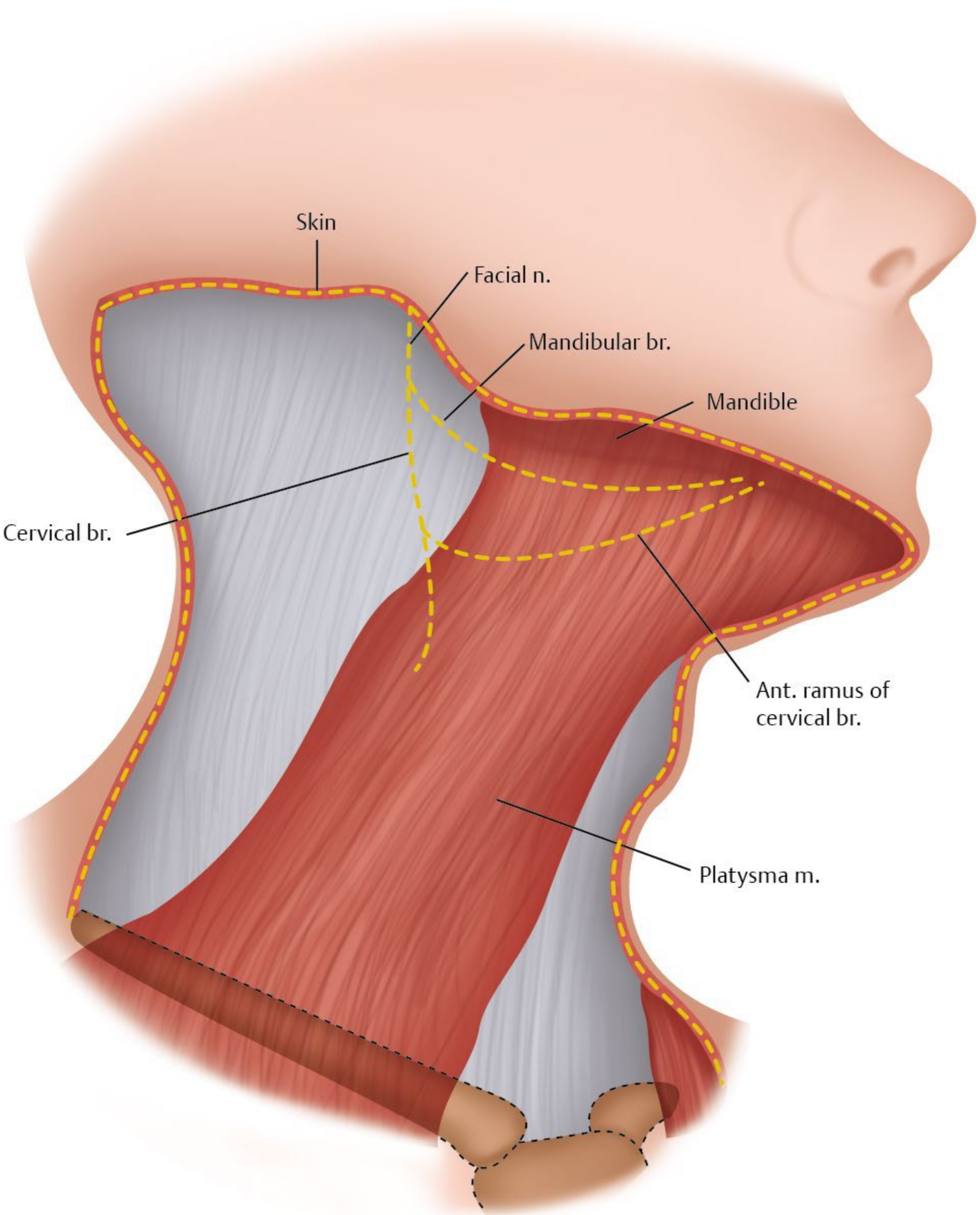

Fig. 21.11 Course of the marginal mandibular nerve.

dissection. During facelift surgery, dissection under the platysma starts superiorly and progresses inferiorly along the posterior border of the muscle. The marginal mandibular branch exits the parotid above the junction between the lower border and anterior aspect of the gland, and the cervical branch exits at the lower border; they need to be protected. Blunt dissection with a small cotton ball is commonly used to provide safe dissection.

Vascular Anatomy of the Neck

Arteries

The carotid arteries are the main arterial structures of the neck (**Fig. 21.12**). The right common carotid artery arises from the brachiocephalic artery, and the left arises from the arch of the aorta. They bifurcate at the level of the upper border of the thyroid cartilage into the internal and external carotid arteries. The internal carotid artery usually does not have any branches in the neck and passes through the carotid canal to the cranium. Branches of the external carotid artery are the superior thyroid, ascending pharyngeal, lingual, facial, occipital, posterior auricular, maxillary, and superficial temporal arteries. The first branch of the external carotid artery is the superior thyroid artery. It arises just below the grater horn of the hyoid bone and runs downward toward the upper pole of the thyroid gland. The artery supplies the thyroid, sternocleidomastoid muscle, infrahyoid muscles, and laryngeal musculature. The facial artery arises from the external carotid artery and runs forward and upward to enter the digastric triangle. It courses deep to the digastric muscle and posterior to the submandibular gland, where it gives rise to the branches to the gland. The artery exits from the superior part of the gland, winding around the inferior border of the mandible, and enters the face along the anterior border of the masseter muscle. In the neck, it gives rise to the ascending palatine, tonsillar, and submental arteries.

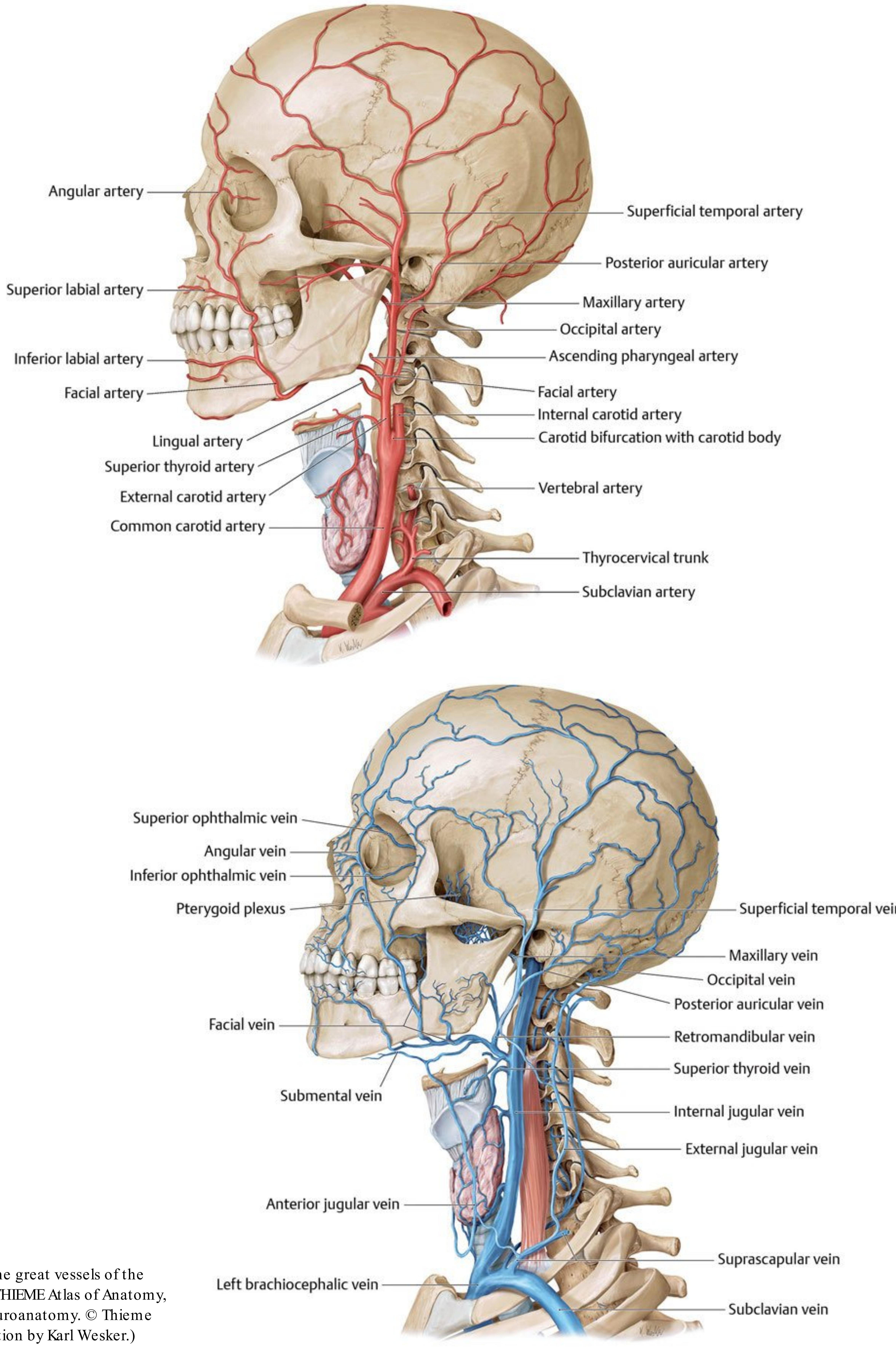

Fig. 21.12 The great vessels of the neck. (From THIEME Atlas of Anatomy, Head and Neuroanatomy. © Thieme 2010, Illustration by Karl Wesker.)

Surgical Annotation

Carotid body tumors arise from the adventitia of the carotid artery bifurcation medially. They often manifest as an asymptomatic lump in the anterior neck, with cranial nerve palsies, or with paroxysmal hypertension and palpitations. The carotid arteries are in imminent danger during neck dissection, and carotid artery blowout can occur in patients who undergo neck dissection and radiotherapy, which can be fatal.[19–21]

Veins

The main veins in the neck are the external and internal jugulars (**Fig. 21.13**). The internal jugular vein emerges from the base of the skull through the jugular foramen, and accompanies the carotid artery within the carotid sheath. It joins the subclavian vein to form the brachiocephalic vein. The important tributaries include the facial, lingual, pharyngeal, superior, and inferior thyroid veins. The external jugular vein originates at the apex of the parotid gland and passes along the lateral border of the sternocleidomastoid muscle, pierces the deep cervical fascia, and drains into the subclavian vein. The tributaries are occipital, posterior external jugular, superficial cervical, suprascapular, and anterior jugular veins. The anterior jugular vein receives veins from the submandibular region and the facial and parotid veins, passes anteriorly in the neck, and drains into the external jugular or subclavian veins. The union of superficial temporal and maxillary veins forms the retromandibular vein. The vein enters the parotid gland superficial to the external carotid artery, between the mandibular ramus and sternocleidomastoid muscle. It divides into anterior and posterior branches. The anterior branch joins the facial vein and become the common facial vein. The posterior branch joins the posterior auricular vein and become the external jugular vein. The relationship of the vein to the facial nerve is important during parotidectomy. In most situations, the vein lies medial to the upper and lower trunks of the facial nerve.

Surgical Annotation

The lower platysma myotomy is sometimes carried out during neck lift surgery. When dissecting along the posterior border of the muscle, care must be taken to avoid injury to the greater auricular nerve. This nerve emerges at the posterior border of the sternocleidomastoid approximately 6 cm below the mastoid and courses anterior and superior. The external jugular vein can be identified under the superficial cervical fascia and below the posterior fibers of the platysma approximately at the level of

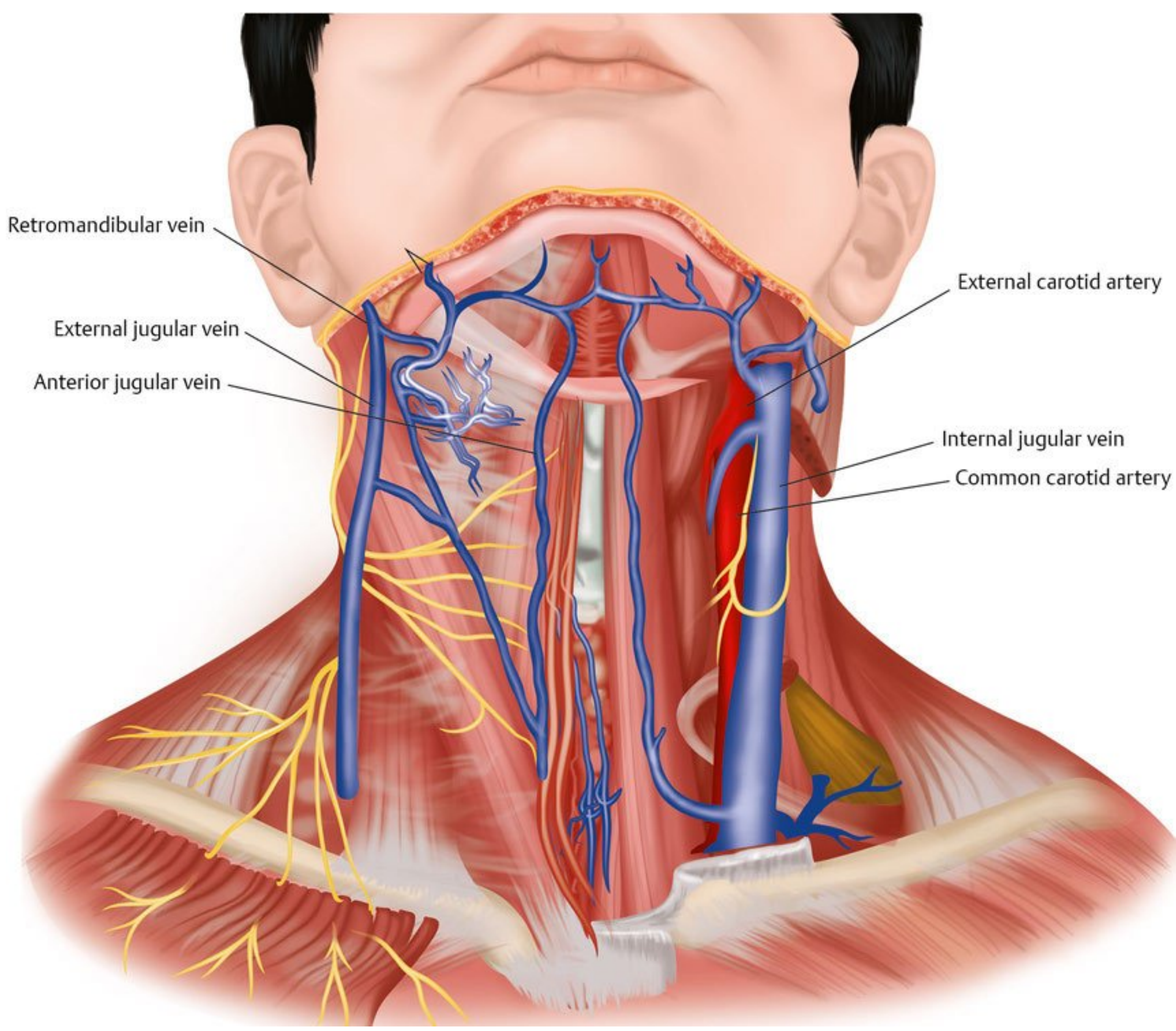

Fig. 21.13 The triangles of the neck.

the cricoid cartilage. Dissection of the posterior platysma fibers with gentle elevation reduces the risk of injury to the vein, which is restrained by the fascia. During radical dissection of the neck, the internal jugular vein is removed along with other structures, which may lead to facial edema as a long-term complication.[22,23]

Lymphatics

The lymph nodes in the neck are broadly classified into superficial and deep groups, and the lymph nodes are found to be in relation to the triangles of the neck. The superficial group consists of submental, submandibular, anterior cervical, and superficial cervical lymph nodes. The deep group consists of infrahyoid, prelaryngeal, pretracheal, retropharyngeal, and deep cervical nodes.

Superficial group drain into the deep group and deep group in turn drain into the jugular trunk. On the left side, the left jugular trunk drains into the thoracic duct. The thoracic duct is the main lymphatic trunk in the body, collecting from all areas except the right side of the head, neck, thorax, and arm. The thoracic duct enters the neck through the thoracic inlet behind the left carotid artery and left vagus nerve. It passes between the left common carotid artery and subclavian arteries and enters the left subclavian trunk. At this point, the duct receives the left subclavian trunk. On the right side, the jugular trunk and subclavian trunk drain into the right lymphatic duct. The right lymphatic duct passes along the medical border of the scalenus muscle to drain into the subclavian vein.

Classification of the Lymph Nodes

- Level 1: Submental (1a), submandibular (1b) (**Fig. 21.14**)
  - Boundaries: The body of the mandible, stylohyoid muscle, anterior belly of the digastric muscle
- Levels 2, 3, and 4: The upper, middle, and lower jugular nodes
  - Level 2 is divided in to 2a and 2b by the spinal accessory nerve.
  - Level 3 nodes boundaries: The hyoid bone and a horizontal plane defined by the inferior border of the cricoid cartilage, sternohyoid muscle, and posterior border of the sternocleidomastoid muscle.
  - Level 4 refers to the group of nodes related to the lower third of the jugular vein.
    Boundaries: Inferior border of the cricoid cartilage, clavicle, sternohyoid muscle, and posterior border of the sternocleidomastoid muscle.
- Level 5 nodes are located in the posterior triangle of the neck.
  - Boundaries: The posterior border of the sternocleidomastoid, anterior border of the trapezius muscle and clavicle. This level is subdivided by a plane defined by the inferior border of the cricoid cartilage into level 5a superiorly and level 5b inferiorly.
- Level 6 nodes are in the anterior, or central, compartment of the neck.
  - Boundaries: Carotid arteries, hyoid bone, suprasternal notch

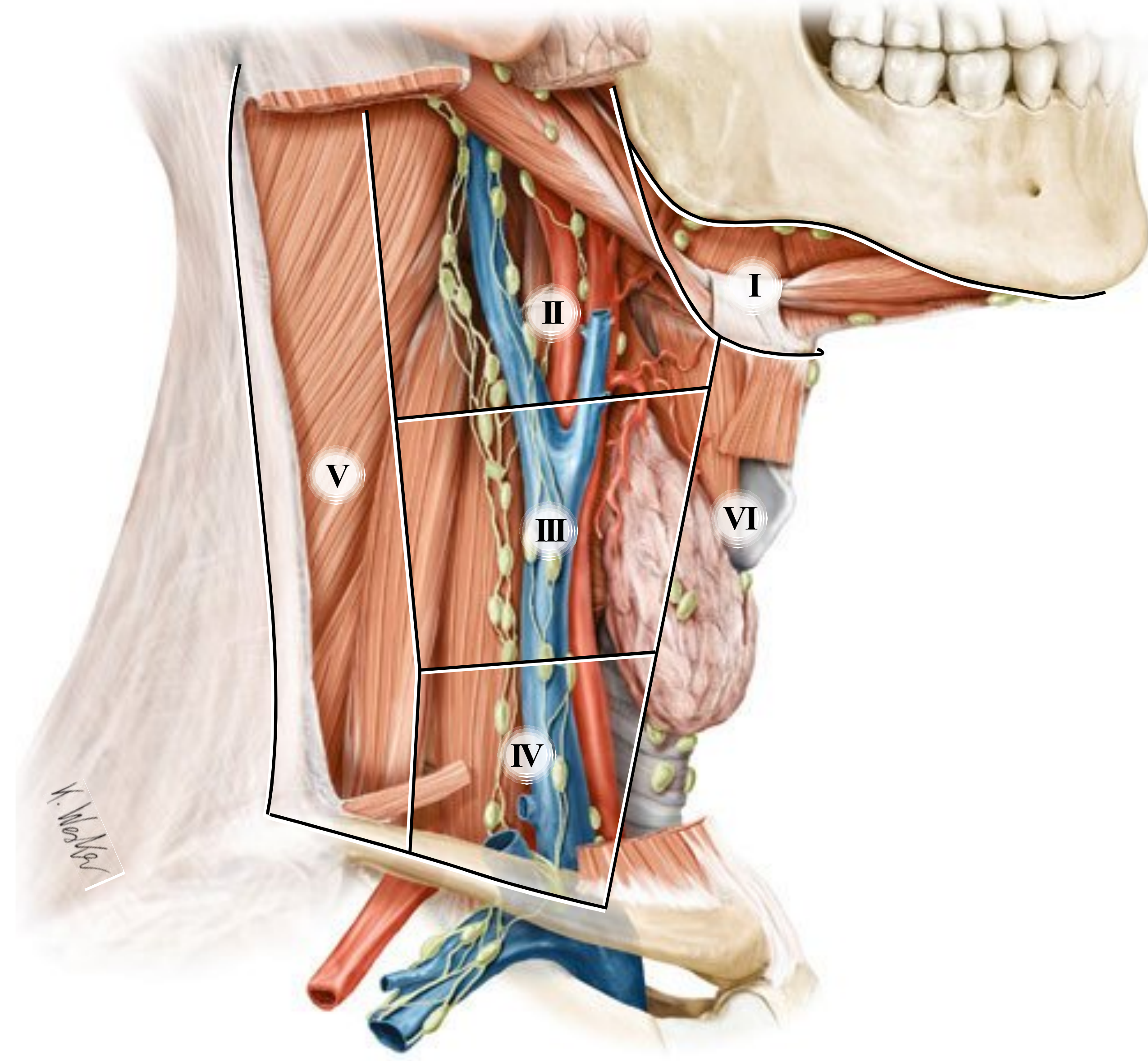

Fig. 21.14 The lymph node of the neck. (From THIEME Atlas of Anatomy, General Anatomy and Musculoskeltal System. © Thieme 2005, Illustration by Karl Wesker.)

Lymph nodes in this compartment are located in the tracheoesophageal groove (paratracheal nodes), in front of the trachea (pretracheal nodes), around the thyroid gland (parathyroidal nodes), and on the cricothyroid membrane (precricoid).

Surgical Annotation

- Metastasis: Level 1a from the floor of the mouth, anterior tongue, anterior mandibular alveolar ridge, and lower lip. Level Ib receives metastases from cancers of the oral cavity, anterior nasal cavity, soft tissue structures of the midface, and submandibular gland.
- Level 2 nodes may be involved in cancers of the oral cavity, nasal cavity, nasopharynx, oropharynx, hypopharynx, larynx, and parotid gland may involve these nodes.
- Level 3 receives metastasis from cancers that originate in the oral cavity, nasopharynx, oropharynx, hypopharynx, and larynx. The nodes of level 4 commonly harbor metastasis from cancer that originates in the larynx, hypopharynx, thyroid, and cervical esophagus.
- Level 5 may harbor metastasis from cancers that arises in the nasopharynx, oropharynx, or skin of the posterior scalp and neck. Lymph nodes in the central compartment are not routinely excised in radical neck dissection; most commonly, they are removed during surgery for thyroid, laryngeal, and hypopharyngeal cancers.[24–27]

Triangles of the Neck

The neck is broadly divided in to anterior and posterior triangles (**Fig. 21.15**).

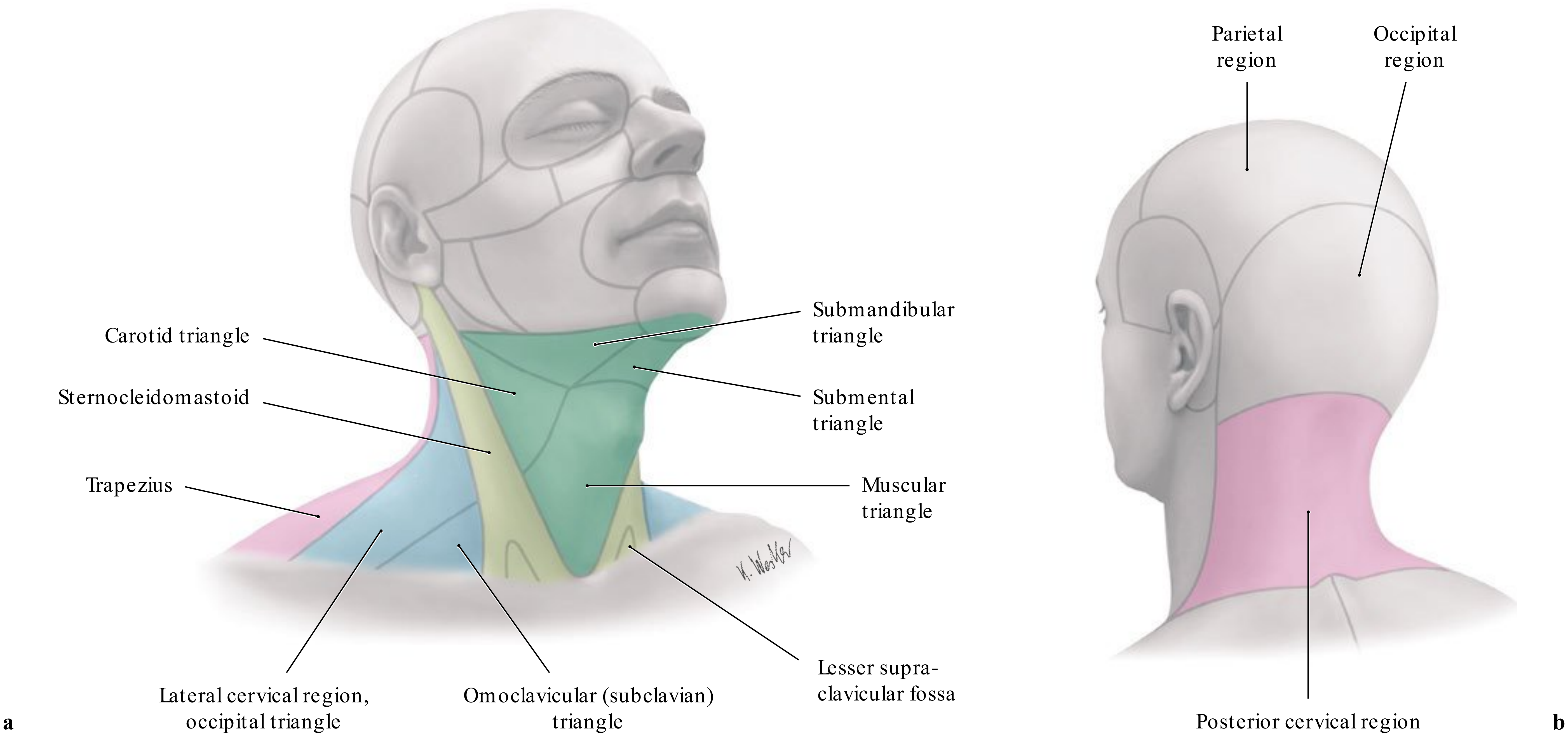

Fig. 21.15 Regions of the neck (cervical regions), right lateral view. For descriptive purposes, the anterior and lateral neck are divided into two triangles which share the sternocleidomastoid as a boundary. (From THIEME Atlas of Anatomy, Neck and Internal Organs. © Thieme 2010, Illustrations by Karl Wesker.)

Anterior Triangle

The anatomical boundaries of the two anterior triangles of the neck commence from the midline of the neck, extending from the sternal notch to the chin. They are bordered posteriorly by the anterior margin of the sternocleidomastoid muscle and superiorly by the inferior border of the mandible. The space can be further divided into submental, submandibular carotid and muscular triangles.

Submental Triangle/Suprahyoid Triangle

The submental triangle, also referred to as the suprahyoid triangle, is bound anteriorly by the anterior belly of the digastric muscle. The hyoid bone forms the inferior border, and the mylohyoid forms the floor of the triangle. The medial border extends up to the midline of the neck. The submental triangle contains the submental lymph nodes and the veins.

Submandibular Triangle/Digastric Triangle

The submandibular triangle is bordered anteroinferiorly and posteroinferiorly by the anterior and posterior belly of the digastric muscle respectively. The lower border of the mandible forms the superior border. The important contents include the submandibular salivary gland, facial artery and vein, and the marginal mandibular nerve.

Carotid Triangle

The carotid triangles contain some of the important structures of the neck. These include the hypoglossal, accessory and vagus nerves, superior laryngeal nerve and branches of the facial nerve, sympathetic trunk, carotid vessels, and the branches of the jugular veins. The anterior border of the carotid triangle is formed by the omohyoid muscle. Posteriorly, it is lined by the sternocleidomastoid muscle and superiorly by the posterior belly of the digastric and stylohyoid muscles. The floor is formed by the middle and inferior pharyngeal constrictors, hyoglossus, and the thyrohyoid muscles.

Muscular Triangle/Inferior Carotid Triangle

The muscular triangle is also referred to as the inferior carotid triangle and contains the sternothyroid and sternohyoid muscles, oesophagus, thyroid gland, and trachea. The space is bordered posteriorly by the anterior border of the sternocleidomastoid muscle. The superior belly of the omohyoid forms the postero superior border, and the space extends up to the midline of the neck from the hyoid bone to the sternum.

Posterior Triangle

The posterior triangle is bounded anteriorly by the posterior border of the sternocleidomastoid muscle. The posterior border is formed by the anterior border of the trapezius, and the inferior border is formed by the middle third of the clavicle. The triangle is further divided into the occipital and subclavican triangle by the inferior belly of the omohyoid. The contents include the spinal accessory nerve, branches of the cervical plexus, roots and trunks of the cervical plexus and phrenic nerve, subclavian and transverse cervical artery, external jugular vein, inferior belly of the omohyoid muscle, scalene, splenius and levator scapulae muscles.

Surgical Annotation

Lymph node status is one of the important prognostic factors for head and neck cancers. Appropriate management of the regional lymphatics, therefore, plays a central role in the treatment of the head and neck cancer patients. The triangles of the neck have oncologic significance related to the surgical management of the regional metastasis.

The neck dissection can be broadly divided into comprehensive or selective. The comprehensive neck dissection is further divided into radical, modified radical, and extended radical dissection. The selective neck dissection includes supraomohyoid, anterolateral, anterior, and posterior dissections. The classification is mainly based on the surgical management of regional lymph nodes and preservation or removal of structures in relation to these nodes.[28,29]

Submandibular Gland

The submandibular gland is located in the submandibular triangle (**Fig. 21.16**). The gland is enveloped by a capsule and has two portions. The superficial lobe is large and is found superficial to the mylohyoid muscle. The gland parenchyma extends along the posterior border of the muscle to form the smaller deep lobe. Wharton's duct arises from the deeper lobe, crosses the sublingual space, and opens near the frenulum of the tongue.

Many important structures are closely related to the submandibular gland and have significant clinical relevance. The marginal mandibular branch of the facial nerve passes along the anteroinferior part of the gland, crosses the mandible, and supplies the muscles of the lower lip and chin. The cervical branches of the facial nerve and the facial vein are related to the anteroinferior part of the gland. The facial artery courses superolaterally, and the deep lobe is closely related to the glossopharyngeal, lingual, and hypoglossal nerves and the submandibular ganglion. The deep surface of the gland overlies the mylohyoid, hyoglossus, styloglossus, stylohyoid, and the posterior belly of the digastric muscle. The lingual nerve lies above and lateral to the duct of the submandibular gland.

Surgical Annotation

Dissection of the gland is often performed in oncologic neck surgery and neck lift procedures, and it is important to acknowledge the close relationship of these structures to the gland.[30] Direct access to the gland in neck and oncologic procedures is through the submandibular approach, whereas the aesthetic resection is carried out via submental approach. With the aging process, there may be pseudoptosis rather than actual descent of the gland in the neck. Anatomical studies have revealed that about 40%of the gland represents the cervical part of the submandibular gland. Partial resection of the prominent gland during neck contouring carries a risk of damage to the facial artery, vein, and marginal mandibular nerve. Dissecting the gland in the subcapsular plane may prevent injury to the nerve.[3,30–32] Submandibular gland excision involves direct access, during which it is important to protect the marginal mandibular branch of the facial nerve. The skin incision is therefore placed approximately 4 cm below the mandibular border, and the platysma muscle needs to be elevated carefully. Intracapsular dissection allows protection of the pericapsular structures as in reduction of the gland. At the upper segment of the dissection, the lingual nerve should be identified superior to Wharton's duct and protected, and the nerve fibers passing to the gland are divided. Intracapsular dissection provides protection to the hypoglossal nerve, which courses over the hyoglossus. When the submandibular gland is reduced during neck lift surgery, access is through the anteroinferior segment of the capsule. To avoid damage to surrounding structures, the dissection needs to remain intra capsular. The relationships of the capsule are the facial nerve and facial artery posterior and superior, the facial vein posterior, and the lingual nerve at the superior border of the gland. The hypoglossal nerve lies to the medial side in the lower two-thirds; depending on the size of the submandibular gland, it takes a transverse course over hyoglossus and passes superior to the mylohyoid muscle.[33,34]

Visceral Structures

The important visceral structures are the pharynx, larynx, trachea, and esophagus. The thyroid, parathyroid, and thymus glands are closely related to these structures. The cervical esophagus begins at the lower border of the cricoid cartilage and takes a curved course down the neck. The recurrent laryngeal nerves, thyroid gland, carotid sheath, and branches of the arteries are related anterolaterally. The thyroid gland consists of two lobes, which may be connected by the isthmus.

Surgical Annotation

Tracheostomy is one of the most common surgical procedures performed in intensive care units. The most common indication for tracheostomy is for prolonged airway access in impaired respiratory function. During tracheostomy, the structures anterior to the second to fourth rings are addressed such as the isthmus of the thyroid. During primary and reoperations of the thyroid glands, it is crucial to appreciate the relationship between the important landmarks, such as the recurrent and superior laryngeal nerves, brachiocephalic artery, and parathyroid glands.[35–37]

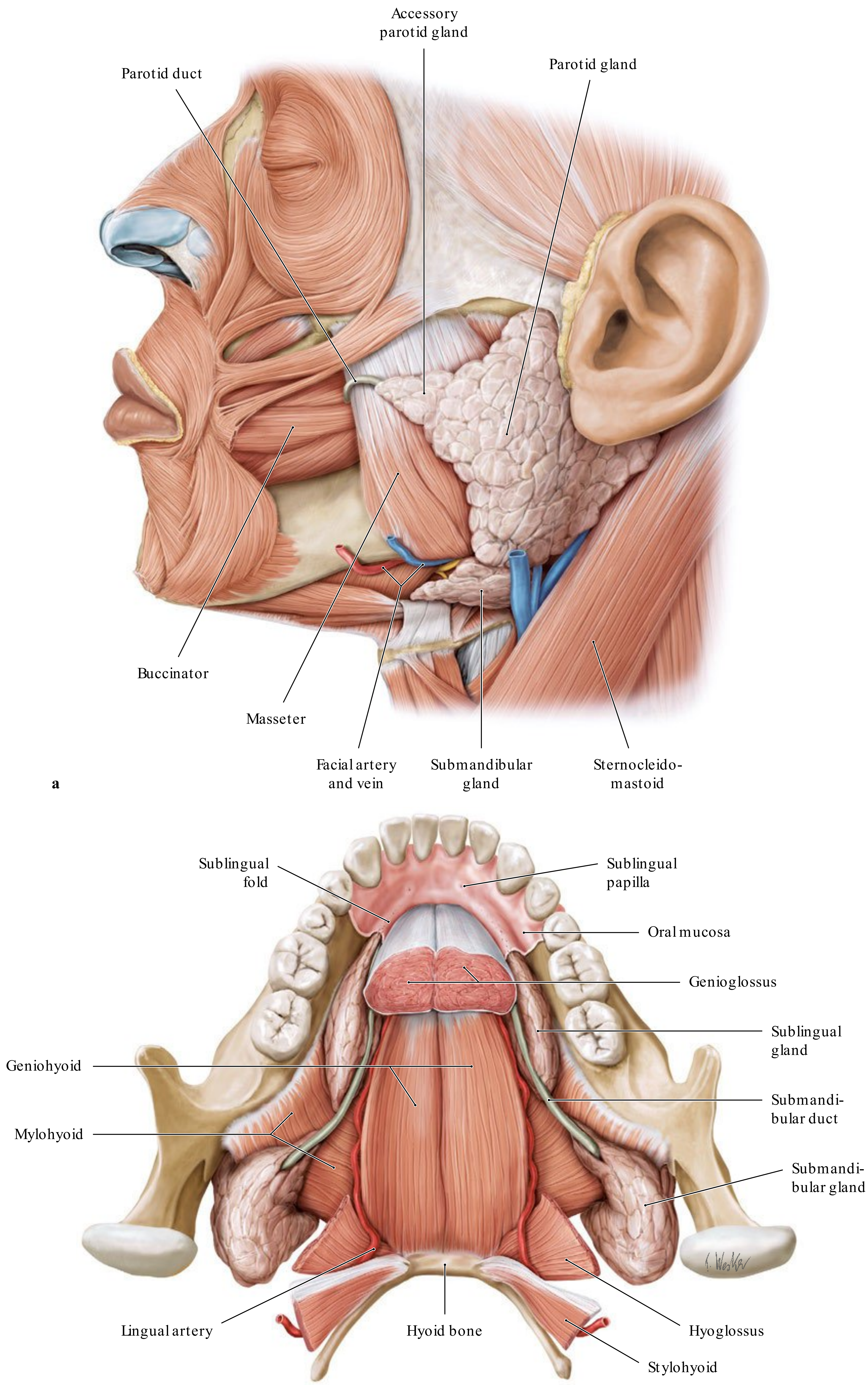

Fig. 21.16 Major salivary glands. **(a)** Lateral view and **(b)** superior view. Three large, paired sets of glads are distinguished: 1. Parotid glands 2. Submandibular glands 3. Sublingual glands. (From THIEME Atlas of Anatomy, Head and Neuroanatomy. © Thieme 2010, Illustrations by Karl Wesker.)

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