



Anatomy of the Facial Nerve

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Abbreviations

acf	Anterior cranial fossa	of	Oval foramen
an	Great auricular nerve	p	Petrous part of temporal bone
ba	Basilar artery	pa	Parotid gland
ca	Internal carotid artery	pcf	Posterior cranial fossa
cf	Cervicofacial division	pl	Platysma muscle
ch	Cerebellar hemisphere	po	Pons
cn2	Optic nerve	rm	Retromandibular vein
cn3	Oculomotor nerve	s	Sella turcica
cn6	Abducent nerve	smf	Stylomastoid foramen
cn7	Facial nerve	sp	Styloid process
cn8	Vestibulocochlear nerve	sta	Superficial temporal artery
eam	Opening of external acoustic meatus	tfa	Transverse facial artery
ejv	External jugular vein	tl	Temporal lobe
fa	Facial artery	va	Vertebral artery
fv	Facial vein	zm	Zygomaticus major muscle
iam	Ostium of internal acoustic meatus		
in	Infundibulum		
jf	Jugular foramen		
la	Labyrinthine artery		
mcf	Middle cranial fossa		
me	Transition zone of medulla spinalis to medulla oblongata		
mm	Masseter muscle		
mp	Mastoid process		
ob	Olfactory bulb		

This chapter will briefly recapitulate the anatomy of the facial nerve. As the facial nerve emerges from cranial nerve (CN)7 as its motoric portion the first part will focus on the anatomical course and diverse targets of CN7. The second part of this chapter contains a detailed description of the facial nerve regarding intracerebral, intracranial, and extracranial anatomical and topological characteristics, and also functional aspects.

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7.1 Cranial Nerve (CN)7

Traditionally cranial nerve (CN)7 is referred to as facial nerve. Together with CN8 it leaves the brain at the cerebellopontine angle (Fig. 7.1) and travels through the subarachnoid space towards the posterior surface of the petrous part of the temporal bone. Here the nerves are joined by the labyrinthine artery and together they enter the internal acoustic opening. On their way through the internal auditory (acoustic) meatus CN7 separates and enters the facial (Fallopian) canal (Fig. 7.2a, b).

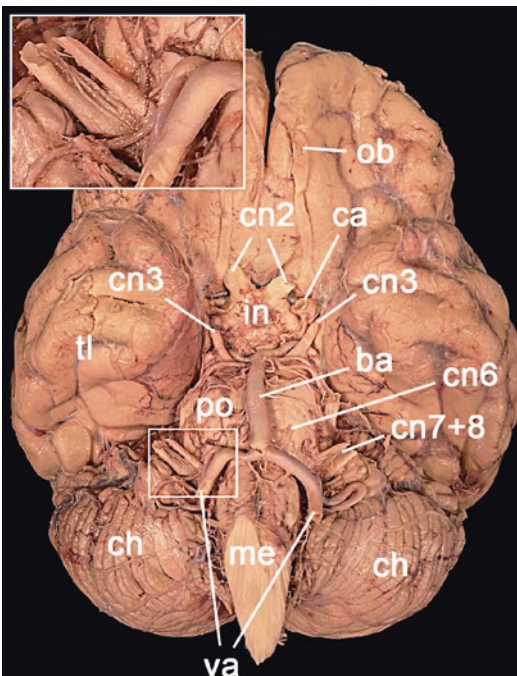


Fig. 7.1 Facial, intermediate, and vestibulocochlear nerve (cn7 + 8) near base of the brain. Inlay shows magnification of right cerebellopontine angle. *tl* temporal lobe, *po* pons, *me* transition zone of medulla spinalis to medulla oblongata, *ch* cerebellar hemisphere, *in* infundibulum, *va* vertebral artery, *ba* basilar artery, *ca* internal carotid artery, *ob* olfactory bulb, *cn2* optic nerve, *cn3* oculomotor nerve, *cn6* abducent nerve, *cn7 + 8* facial and vestibulocochlear nerve

The fallopian canal and the nerve inside have three segments: The first (labyrinthine segment) is very short and oriented fronto-laterally, the second (tympanic segment) is oriented occipito-laterally, and the third (mastoid segment) descends until the canal terminates at the stylo-mastoid foramen (Fig. 7.2c, d). The nerve leaves the canal through this opening. At the transition of the labyrinthine to the tympanic segments the canal and CN7 form an acute curve, the (second) geniculum, which contains the genicular ganglion with sensory nerve bodies.

While running inside the facial canal, various branches leave CN7. The greater petrosal nerve branches off where the nerve forms the geniculum. The chorda tympani, the stapedial nerve, and a branch joining the auricular branch of the vagus nerve (Arnold's nerve) leave the mastoid segment [1].

7.1.1 Targets of CN7

The branches of CN7 innervate the derivatives of the material derived from the mesenchyme of the second pharyngeal (branchial) arch. They comprise general and special sensory, parasympathetic, and motoric fibers or combinations. Motor targets are the stapedius muscle, mimic, auricular, and posterior suprahyoid muscles. Parasympathetic targets are the lacrimal gland, two salivary glands (sublingual and submandibular), and small glands and the mucosa of the palatine and nasopharynx. General sensory targets are small areas at and near the auricle and the external acoustic meatus. Special sensory targets are taste buds in the anterior two-thirds of the tongue and scattered buds on the hard and soft palate.

Between the cerebellopontine angle and the Fallopian canal, the sensory and parasympathetic fibers run together and form the nervus intermedius (intermediate nerve of Wrisberg), which is

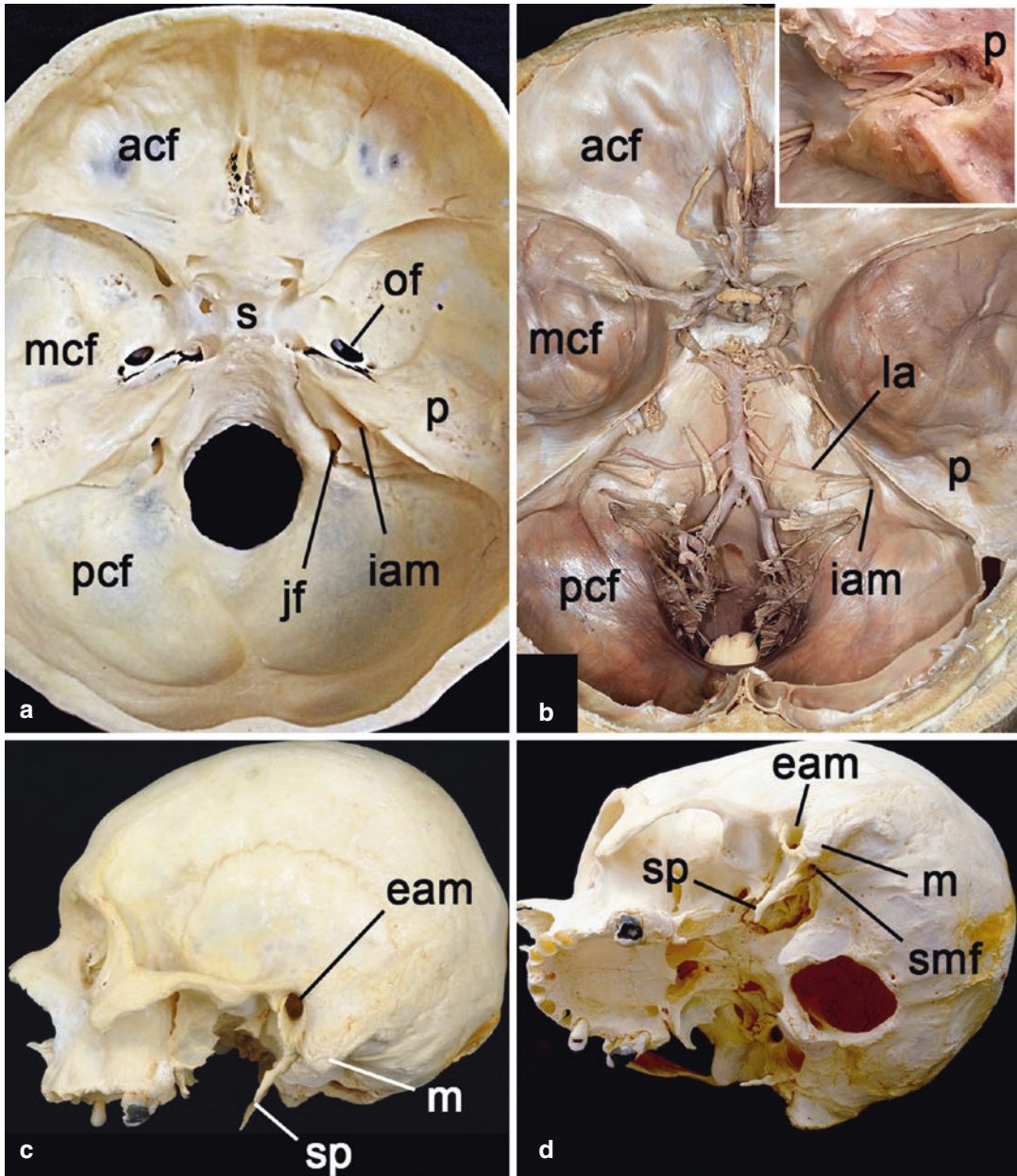


Fig. 7.2 Key features along the passage of facial nerve through cranium. (a, b) Features of internal skull base without (a) and in association with dura mater, nerves, and brain arteries (b). The roof of the internal acoustic meatus and the labyrinthine segment of the facial canal are removed in the inlay. (c, d). Topology of the stylomastoid foramen. *acf* anterior cranial fossa, *mcf* middle cra-

nial fossa, *pcf* posterior cranial fossa, *s* sella turcica, *p* petrous part of temporal bone, *of* oval foramen, *jf* jugular foramen, *iam* ostium of internal acoustic meatus, *la* labyrinthine artery, *eam* opening of external acoustic meatus, *sp* styloid process, *m* mastoid process, *smf* stylomastoid foramen

part of CN7, but separated from its motoric portion. At the level of the geniculum of CN7, the perikaryon of the sensory neurons form the geniculate ganglion.

7.2 Facial Nerve: Motoric Portion of CN7

In addition to its use for describing CN7, the term facial nerve is used for referring to the (branchial) motor portion of CN7 only. This chapter will make use of this definition and focus on the description of the motoric portion of CN7.

7.2.1 Intracerebral Segment

The motor nuclei of the facial nerve are located in the ventral rhombencephalon near the midline. They receive excitatory fibers from neurons sitting in the motor cortices, which are mainly the precentral gyri of the frontal telencephalic lobe. Their axons travel via the internal capsule and the cerebral peduncles towards the nuclei as part of the corticonuclear tracts. In the rhombencephalon, the majority of the corticonuclear fibers cross sides and enter the contralateral motor nucleus of the facial nerve. A smaller amount of fibers enters the ipsilateral nucleus.

The fibers from the contralateral primary motor cortex form synapses with neurons targeting all muscles innervated by the facial nerve. The smaller amount of corticonuclear fibers that do not cross sides and enter the ipsilateral nucleus solely terminate at neurons targeting muscles of the upper face. Hence, the neurons of the motor nucleus of the facial nerve sending fibers towards the muscles of the upper face, including the orbicularis oculi muscle, can be activated by the contralateral and the ipsilateral primary motor cortex. The rest of the neurons and thus all other facial muscles can only be activated by the contralateral primary motor cortex.

The axons leave the nucleus of the facial nerve medially and ascend towards the floor of the fourth ventricle. They circumvent the nucleus of the sixth cranial nerve dorsally, thereby elevating the rhomboid fossa to form the facial colliculus. Then the fibers descend towards the cerebello-pontine angle passing ventromedially to the spinal nucleus of the trigeminal nerve.

7.2.2 Intracranial Segment

After leaving the brain the motor fibers run as part of CN7, but separated from the sensory and parasympathetic fibers of the intermediate nerve towards the fallopian canal (see above). Fibers innervating the stapedius muscle leave the mastoid segment and the rest of the motoric fibers then pass through the stylomastoid foramen.

7.2.3 Extracranial Segment

Positioned between the styloid and mastoid processes, the facial nerve forms the posterior auricular branch and sends branches to the stylohyoid and posterior venter of digastric muscles. In addition, either the digastric ramus or the main stem sends communicating fibers to the glossopharyngeal nerve (Haller ansa).

The posterior auricular branch ascends dorsal to the auricle and connects with the vagus, the posterior branch of the great auricular and the lesser occipital nerve. It innervates the occipital belly of the epicranium muscle and, together with the temporal branch of the facial nerve (see 7.2.5) the auricular muscles.

7.2.4 Parotid Plexus

After submitting these branches, the stem of the facial nerve enters the tissues of the parotid gland. It comprises up to 4.000 nerve fibers and bifur-

cates into a temporofacial and a cervicofacial division [2]. The temporofacial division is joined by a branch of the auriculotemporal nerve, which provides parasympathetic and sympathetic secretory fibers for the innervation of the parotid gland. The secretory fibers use the branches of the facial nerve to distribute in the parotid gland. The perikarya of the parasympathetic fibers are located in the otic ganglion and can be activated by fibers originating from perikarya in the inferior salivatory nucleus and travel to the ganglion via the glossopharyngeal, tympanic, and finally lesser petrosal nerve (Jacobson anastomosis). The sympathetic fibers originate from perikarya in the superior cervical ganglion.

Still inside the parotid gland the temporofacial and cervicofacial divisions form five large branches: the temporal, zygomatic, buccal, mandibular, and cervical branch. The temporal and zygomatic branches derive from the temporofacial division, the mandibular and cervical branch from the cervicotemporal division. The buccal branch leaves either the one or the other, or in a small proportion of individuals has two roots, one from each division. The course of these branches can be classified using various classification schemes [3]. In principle, the branches either simply form sub-branches that spread to reach their targets, or they exchange fibers in a simple or rather complex way, thereby forming a plexus inbetween the superficial and profound parts of the gland.

Either way, the branches leave the gland at its superior, anterior, and inferior borders to enter the more superficial layers of the face. As the branches emerge from the gland, especially the temporal branch has already formed up to five and the zygomatic branch up to three sub-branches. The buccal branch stays a single nerve strand in approximately half of the population, while in the rest it has ramified into two or three sub-branches. The mandibular (in more than 80%) and cervical branch (in more than 90%)

usually leave the parotid gland as single nerve strands [4, 5] (Fig. 7.3).

7.2.5 Innervation of Facial Muscles

In the face, the branches continue relatively straight towards the muscles. The mandibular branch usually runs inferior to the mandible [6]. All branches have complex variable topologic relations to anatomic structures such as the facial and transverse facial artery and vein, the parotid duct (Stensen duct), or the tissue compartments of the face [7]. Despite of these variations, several authors successfully defined landmarks for targeting nerve branches through the intact skin or for identifying skin regions and strata which are free of larger nerve branches [8–10].

Anatomical textbooks and studies differ slightly in their descriptions of the facial muscle innervation. This is mainly due to a high degree of individual variation in the topology, branching pattern, and communications between facial nerve branches (Fig. 7.4). According to Gray's textbook of human anatomy, the cervical branch innervates the platysma, the mandibular branch the risorius and muscles of the lower lip and chin. The buccal branch supplies the muscles of the cheek and upper lip and small nasal muscles, the zygomatic branch the orbicularis oculi muscle. The temporal branch innervates the anterior and superior auricular muscles, the frontal belly of the occipitofrontal muscle, and supraorbital muscles [11]. Yet details regarding facial muscle innervation are under heavy dispute [12, 13].

Near their targets the facial nerve branches ramify extensively before and while entering the muscles. Especially these small rami exchange fibers with the branches of the trigeminal nerve and it is hypothesized that those fibers might conduct proprioceptive information. The cervical branch often directly communicates with large branches of the transverse cervical nerve,

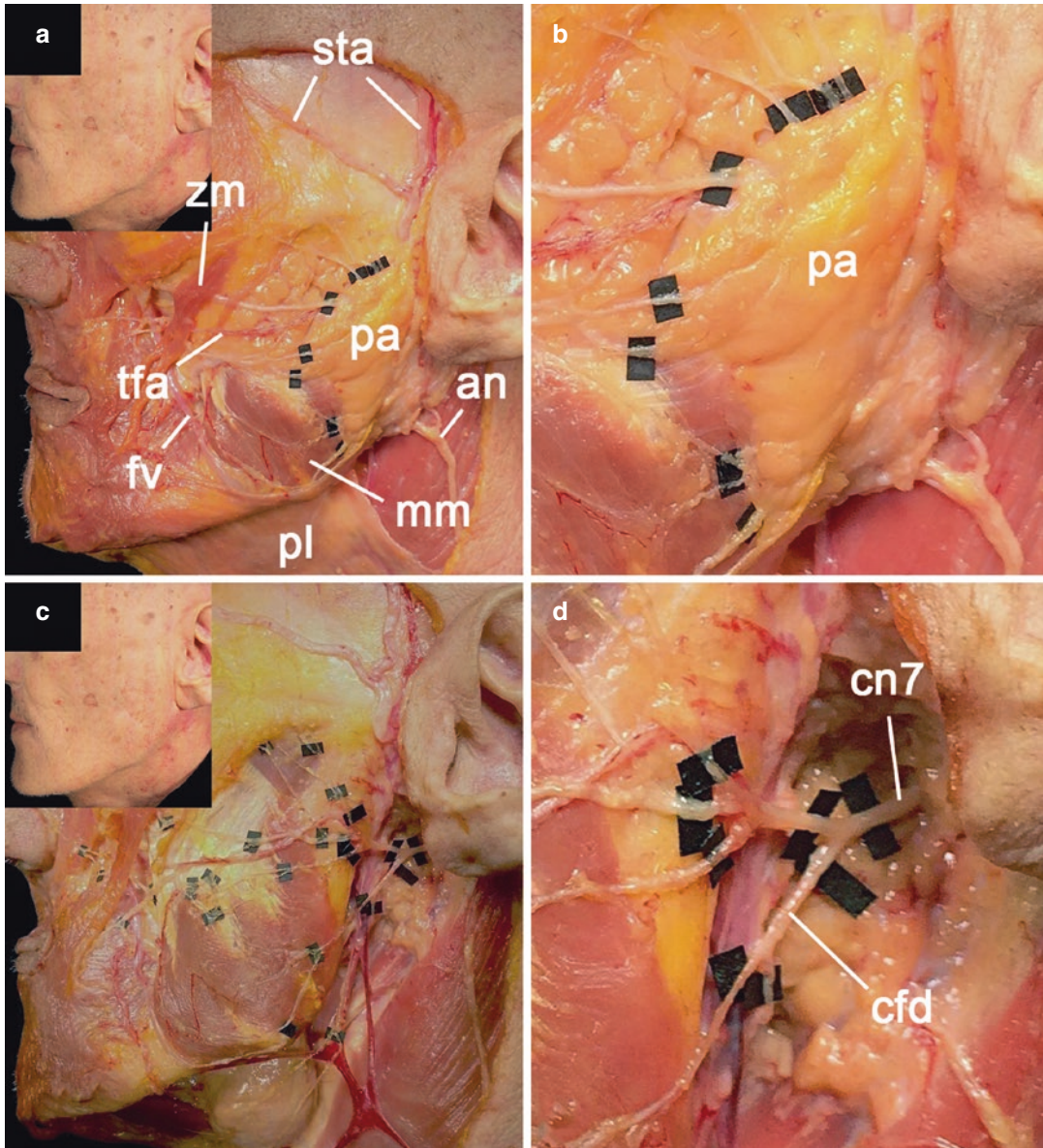


Fig. 7.3 Ramification of the facial nerve (cn7). (a, b) Branches of CN7 leaving the borders of the parotid gland (pa). (c, d) Ramification of the stem of the facial nerve immediately distal to the stylomastoid foramen. Note the bifurcation into temporofacial and cervicofacial (cfd)

division. *sta* superficial temporal artery, *zm* zygomaticus major muscle, *pa* parotid gland, *tfa* transverse facial artery, *fv* facial vein, *pl* platysma muscle, *mm* masseter muscle, *an* great auricular nerve, *cfd* cervicofacial division, *cn7* facial nerve

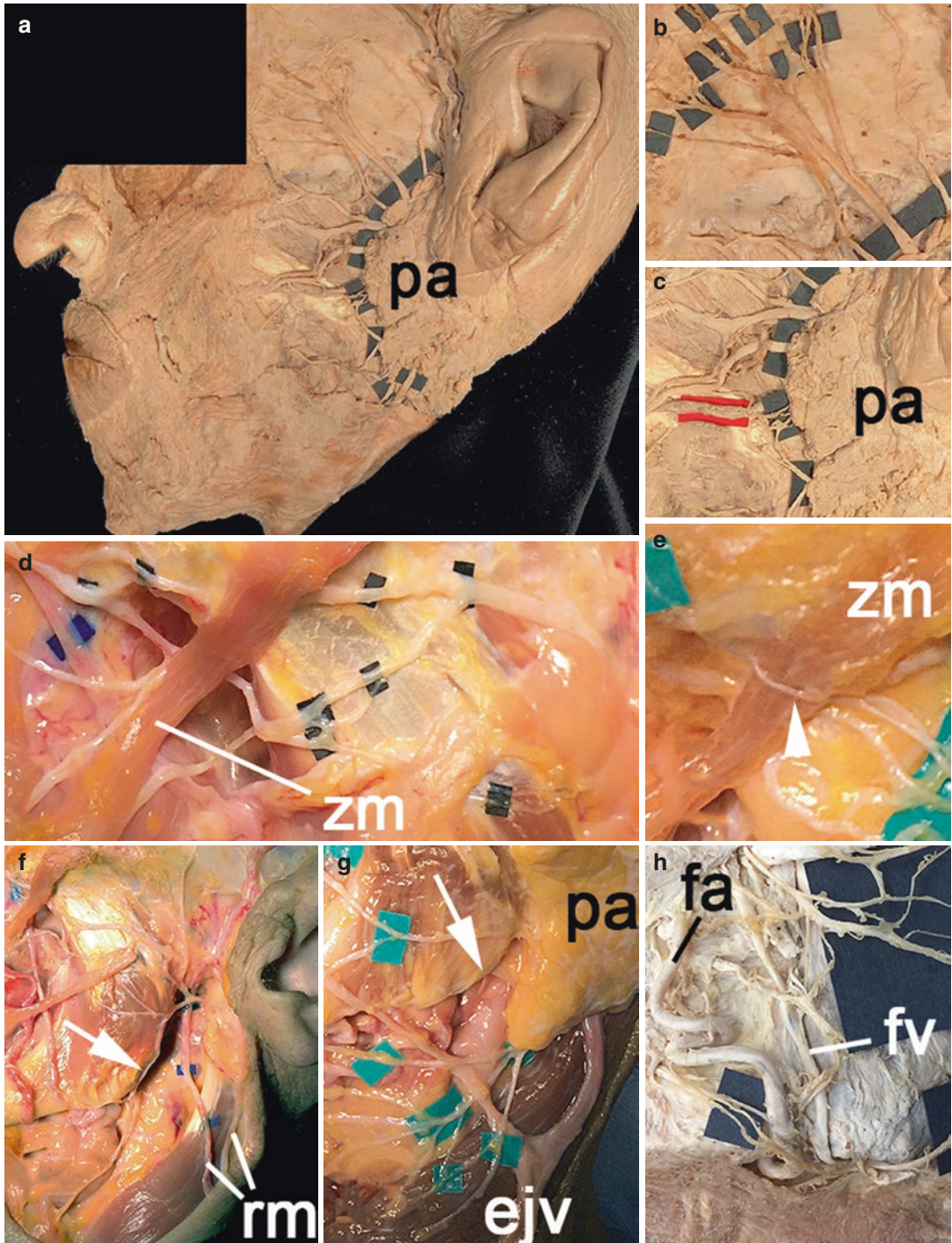


Fig. 7.4 Variations in the topology of the branches of the facial nerve (CN7). (a, b) Overview (a) and detailed (b) ramification of branches after exiting the parotid gland. Note the extensive ramification of temporal nerve branches before entering target muscles (b). (c–e) Zygomatic branches can cross the parotid duct (red background, c), form a plexus in the masseteric region (d) and run underneath (d) or around (arrowhead, e) the zygomaticus major muscle (zm). (f, e). The

cervicofacial division can either ramify inside the parotid gland (d) or later in its course around the mandibular angle (arrow, f). The mandibular branch usually runs inferior to the mandible (f), and further crosses the facial artery and vein (h). The cervical branch can cross the external jugular vein and if so, can run above or underneath it (g). *pa* parotid gland, *zm* zygomaticus major muscle, *rm* retromandibular vein, *ejv* external jugular vein, *fa* facial artery, *fv* facial vein

a sensible nerve originating from the second and third cervical nerves, but also with the glosso-pharyngeal nerve. In general, many constant and inconstant connections between facial nerve branches and cranial and spinal nerves are described [14].

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