Thomas von Arx[1]
Marc J. Nakashima[2]
Scott Lozanoff[2]

[1] Department of Oral Surgery and Stomatology, School of Dental Medicine, University of Bern, Bern, Switzerland
[2] Department of Anatomy, Biochemistry and Physiology, John A. Burns School of Medicine, University of Hawai'i, Honolulu, USA

CORRESPONDENCE
Prof. Dr. Thomas von Arx
Klinik für Oralchirurgie und Stomatologie
Zahnmedizinische Kliniken der Universität Bern
Freiburgstrasse 7
CH-3010 Bern
Tel. +41 31 632 25 66
Fax +41 31 632 25 03
E-mail: thomas.vonarx@zmk.unibe.ch

SWISS DENTAL JOURNAL SSO 128: 678–688 (2018)
Accepted for publication: 23 January 2018

The Face – A Musculoskeletal Perspective

A literature review

KEYWORDS
Anatomy
Face
Muscles
Bones
Fasciae

SUMMARY

The individual appearance and facial expression are based on the musculoskeletal system of the face. The bones of the face contribute to the anterior portion of the skull. This region is also referred to as the facial skeleton or viscerocranium. The muscles of the face include all mimetic muscles innervated by the cranial nerve VII (facial nerve). Two masticatory muscles (masseter, temporalis) that are supplied by the motoric portion of the cranial nerve V3 (mandibular nerve) also contribute to the contour of the face. The mimetic muscles (also known as facial muscles or skin muscles) generally originate from underlying bone surfaces and insert to the skin of the face or intermingle with other facial muscles. This complex musculature contributes to the functioning of the orofacial sense organs and the mediation of emotional and affective states (facial expression). Other soft tissue components of the face include the fasciae and fat compartments. The face commonly exhibits a superficial and a deep fascia, and various facial fat compartments are present.

Introduction

This is the third article regarding anatomical aspects of the face. While the previous two articles addressed the neurosensory and vascular supply of the face (von Arx et al. 2017, 2018), this review covers the muscles and bones of the face. The skeletal framework of the face includes several bones, but also cartilaginous structures. While some of the bones are single (frontal bone, mandible), others are paired (nasal bone, os maxilla). The main muscles of the face include the mimetic musculature extending from the forehead to the chin. All facial muscles are innervated by the facial nerve (CN VII). Two masticatory muscles, the masseter and temporal muscles, also contribute to the face by their superficial location. Other important structures belonging to the musculoskeletal components of the face include the superficial and deep fasciae.

The musculoskeletal system of the face directly influences the individual appearance and contributes to facial expression. The human face also shows the greatest mobility and facial display repertoire among all primates (Burrows et al. 2016). Facial muscular palsy, facial asymmetry, or any other facial changes, should be noted by the dentist to rule out any underlying dentoalveolar pathology, malformation, or trauma.

As in our previous articles, the musculoskeletal structures of the face are presented with regard to the different subunits of the face (Fig. 1).

Bones of the face

The bones of the face contribute to the anterior portion of the skull (Fig. 2 and 3). This region is also referred to as the facial skeleton or viscerocranium.

Forehead

The single frontal bone (os frontale) is the osseous structure of the forehead. It contains the frontal sinus. With its superciliary arches (brow ridges), the frontal bone forms the upper borders of the rostral opening of the orbital cavities. This bony rim also contains the supraorbital notch (or foramen) that is located at the level between the middle and medial thirds of the superciliary arch. The frontal bone may show a single elevation called glabella positioned approximately between the eyebrows. Occasionally, bilateral bony prominences are present within the upper-lateral corners of the frontal bone, termed frontal eminences. The frontal bone is generally considered part of the neurocranium since it forms the wall of the anterior cranial fossa. The frontal bone has articulations with the parietal bones (superiorly and posteriorly), the sphenoid bone and ethmoid bones (inferiorly), the zygomatic bones (inferolaterally), as well as the nasal bones, the lacrimal bones and the os maxillae (inferomedially).

Eyes

The facial (rostral) parts of the orbital cavities include several bones contributing to the orbital rim. The superior margin is formed by the frontal bone, the lateral margin by the zygomatic bone, the inferior margin by the zygomatic bone as well as the os maxilla, and the medial margin by the frontal process of the os maxilla, the lacrimal bone as well as the frontal bone. At the junction of the lacrimal bone and the os maxilla between the inferior and medial orbital rims is the osseous orifice of the nasolacrimal duct.

Nose

The skeletal framework of the nose is bony (upper part) as well as cartilaginous (lower and lateral parts). The root of the nose is formed centrally by the paired nasal bones and laterally by the frontal processes of the os maxillae. The lower portion of the nose includes several cartilages. The central nasal ridge is formed by the superior margin of the nasal septum. The nasal wings consist of the triangular-shaped lateral cartilages (also called upper lateral cartilages). The edges of the nasal orifices and the columella are formed by the alar cartilages (also called lower lateral cartilages). The latter are scroll-shaped around the external openings of the nares (Hafezi et al. 2010). Furthermore, small cartilages contribute to the nasal wings (minor alar cartilages or sesamoid cartilages).

Lips

The lips contain no hard tissues but they are supported by the alveolar processes of the os maxillae (upper lip) and of the mandible (lower lip), respectively.

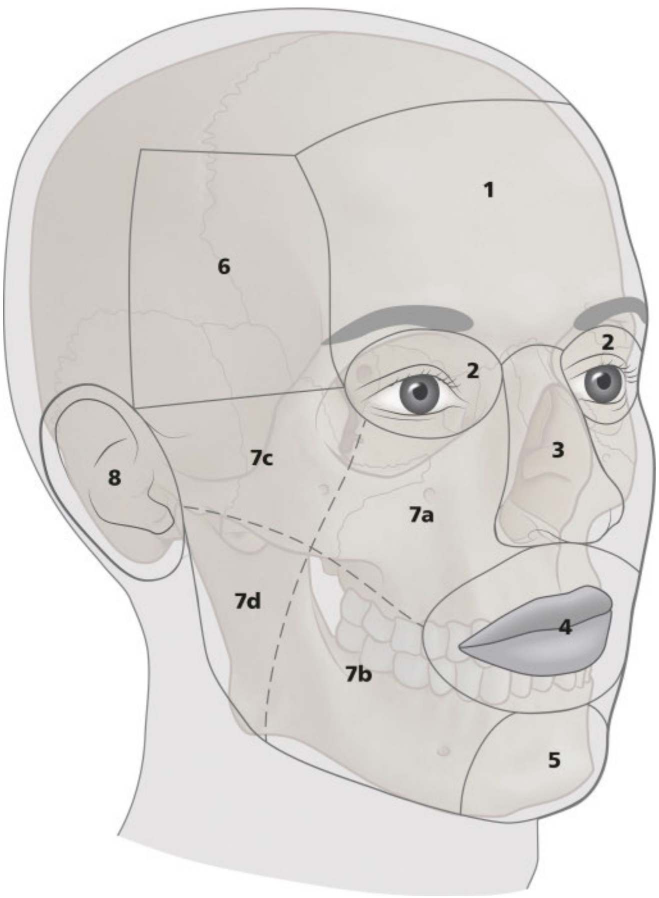

Fig. 1 Illustration of facial subunits projected over skeletal framework of skull: 1 = forehead; 2 = eyes; 3 = nose; 4 = lips; 5 = chin; 6 = temple; 7a = cheek: infraorbital region, 7b = cheek: buccal region, 7c = cheek: zygomatic region, 7d = cheek: parotid-masseteric region; 8 = ear

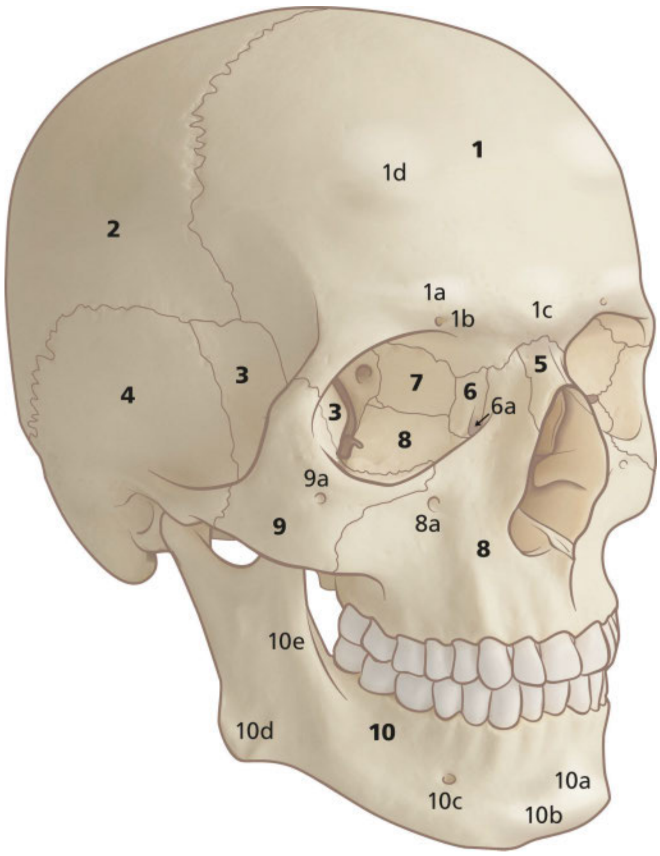

Fig. 2 Osseous components of skull: 1 = os frontale, 1a = superciliary arch, 1b = supraorbital foramen, 1c = glabella, 1d = frontal eminence; 2 = parietal bone; 3 = sphenoid bone; 4 = temporal bone; 5 = nasal bone; 6 = lacrimal bone, 6a = osseous orifice of nasolacrimal duct; 7 = ethmoid bone; 8 = os maxilla, 8a = infraorbital foramen; 9 = zygomatic bone, 9a = zygomaticofacial foramen; 10 = mandible, 10a = symphysis, 10b = mental protuberance, 10c = mental foramen, 10d = angle of mandible, 10e = ramus of mandible

Chin

The chin is formed by the most anteroinferior portion of the mandible (also known as the mandibular symphysis). The mental protuberances are bony prominences located laterally to the lower midline of the mandible. Small openings (nutrient canals) are frequent in this area of the mandible. Occasionally larger orifices of bony canals connecting to other canals or traversing the anterior mandible are present (Trikeriotis et al. 2008).

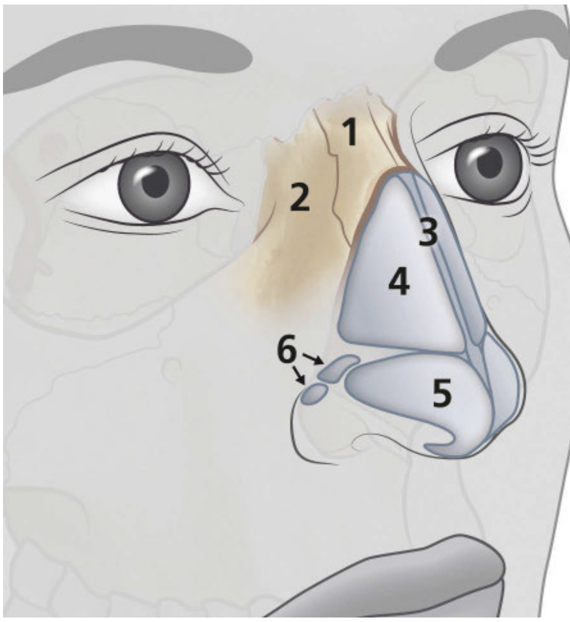

Fig. 3 Osseous and cartilaginous components of the nose: 1 = nasal bone; 2 = nasofrontal process of os maxilla; 3 = superior margin of nasal septum; 4 = upper lateral cartilage; 5 = lower lateral cartilage; 6 = minor alar cartilages

Temple region

The temples are located at the inferolateral aspects of the cranial vault. The bones that contribute to the temples include the sphenoid bone (external surface of greater wing), the temporal bone (anterior part of squamous portion), parietal bone (anteroinferior part), and the frontal bone (inferoposterior part).

Cheeks

The bone of the posterosuperior part (zygomatic region) of the cheek is the os zygomaticum (zygomatic or malar bone). The zygomatic bone is the most laterally located bone of the facial skeleton (cheek prominence). Each zygoma connects the facial and cranial bones through sutures and includes articulations with the frontal, maxillary, sphenoid, and temporal bones. The zygomata are the origins for the masticatory masseter muscles (Dechow & Wang 2016). There may be up to four zygomaticofacial foramina for delivering branches of the homonymous arteries and nerves to the skin in that area (Loukas et al. 2008; Kim et al. 2013). In humans, the zygoma is of esthetic significance for facial appearance (Dechow & Wang 2016). A very prominent zygomatic bone might give an aggressive look.

Fig. 4 Muscles in the forehead area: 1 = frontalis (frontal belly of occipitofrontalis); 2 = procerus; 3 = depressor supercilii; 4 = corrugator supercilii

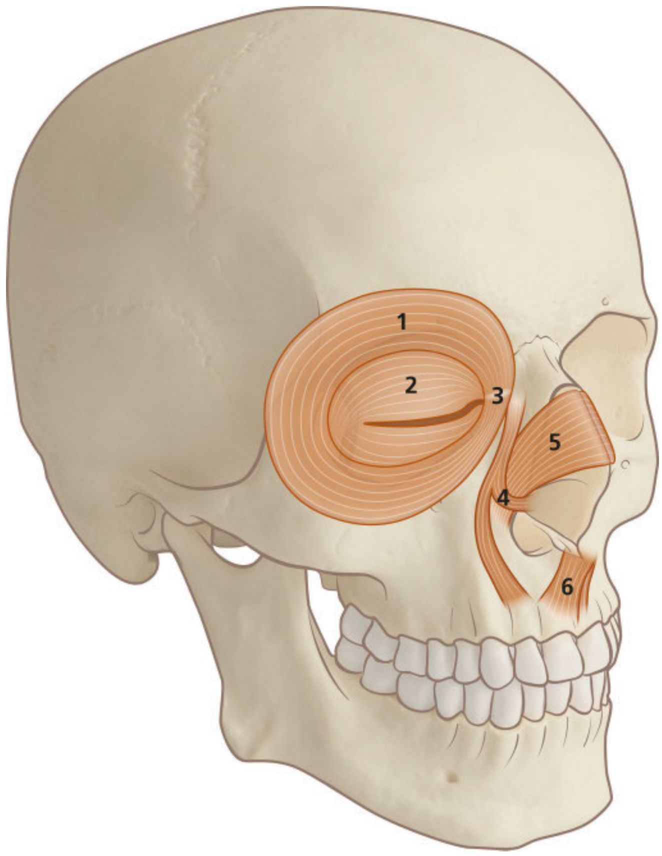

Fig. 5 Periorbital and nasal muscles: 1 = orbital part of orbicularis oculi; 2 = palpebral part of orbicularis oculi; 3 = medial canthal tendon; 4 = medial part of levator labii superioris alaeque nasi; 5 = nasalis; 6 = depressor septi nasi

The underlying bone of the infraorbital region of the cheek is the main body of the os maxilla whereas the lateral surface of the mandibular body and ramus contribute to the lower regions of the cheek.

Ears/auricles

The external ear (auricle) is made up of a single cartilage that forms several elevations (helix, tragus) and depressions (cavum conchae).

Muscles of the face

The muscles of the face include all mimetic muscles but also masticatory muscles. The mimetic muscles (also known as facial muscles or skin muscles) generally originate from underlying bone surfaces and insert to the skin of the face or intermingle with other facial muscles (Fig. 4–13). The independently controlled subcomponents of this complex musculature are of great importance for the functioning of the orofacial sense organs and the mediation of emotional and affective states (facial expression) (Hur et al. 2014).

The facial nerve (CN VII) is the motor nerve of the mimetic muscles. The facial nerve originates from two nuclei in the brainstem and the motor branch runs through the stylomastoid foramen to the viscerocranium. Within the parotid gland, the facial nerve splits into a superior temporofacial division and into an inferior cervicofacial division. Eventually, five major branches of the facial nerve innervate the mimetic musculature: temporal, zygomatic, buccal, marginal mandibular, and cervical rami. The branching pattern of the facial nerve is highly variable and complex, and often shows neural connections with nerves of all three divisions of the trigeminal nerve (Kwak et al. 2004; Diamond et al. 2011).

Forehead

The muscles of the forehead can be divided into superficial (frontalis, procerus), intermediate (depressor supercilii), and deep muscles (corrugator supercilii) (Daniel & Landon 1997). Furthermore, they can be separated in two antagonistic groups with regard to their action on the eyebrows. The eyebrow elevator is the frontalis muscle, whereas the eyebrow depressors include the procerus, the corrugator supercilii, the depressor supercilii, but also the orbicularis oculi (Abramo et al. 2016; Pinar et al. 2016).

The main muscle of the forehead is the (paired) frontal belly of the occipitofrontalis muscle. It is a flat and broad muscle originating from the aponeurosis on the scalp and inserting in the skin above the eyebrows. The single procerus muscle is located in the region of the glabella and runs from the nasal root to the skin overlying the lower central portion of the forehead. Frontalis and procerus muscles both result in transverse wrinkling of the skin (frowning).

Hur (2017) studied in detail the procerus muscle in 53 Korean cadavers. He described fibers of the procerus merging and intermingling with the frontalis, lateral fibers of the procerus to extend and connect with the transverse part of the nasalis muscle, and blending of medial fibers of the LLSAN into the lateral portion of the procerus.

The corrugator supercilii muscle (CSM) has an oblique course and runs superolaterally from the medial supraorbital rim to the skin above the eyebrow. The CSM produces vertical wrinkling over the glabella. A recent systematic review about the CSM

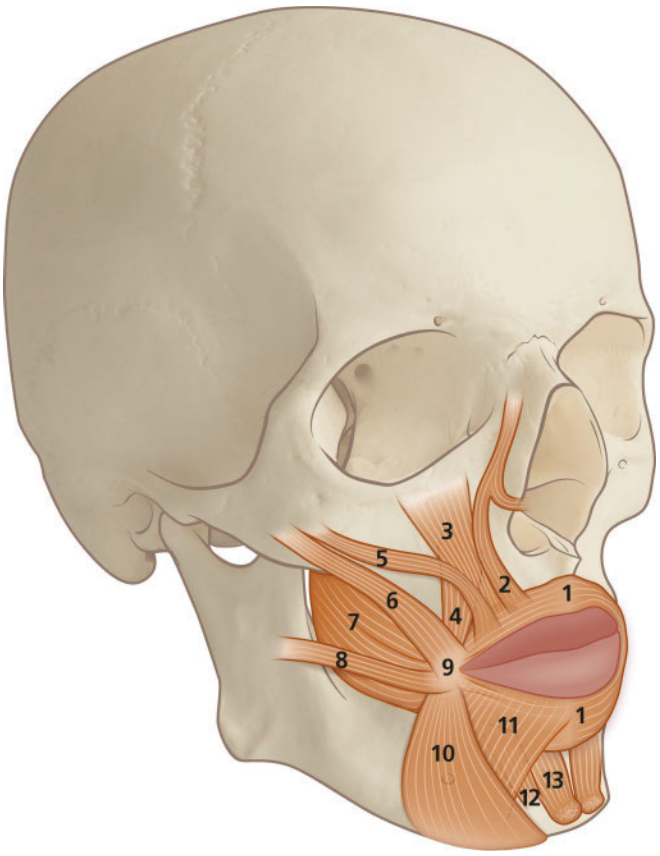

Fig. 6 Lip and cheek muscles: 1 = orbicularis oris; 2 = lateral part of levator labii superioris alaeque nasi; 3 = levator labii superioris; 4 = levator anguli oris; 5 = zygomaticus minor; 6 = zygomaticus major; 7 = buccinator; 8 = risorius; 9 = modiolus; 10 = depressor anguli oris; 11 = depressor labii inferioris; 12 = incisivus labii inferiors; 13 = mentalis

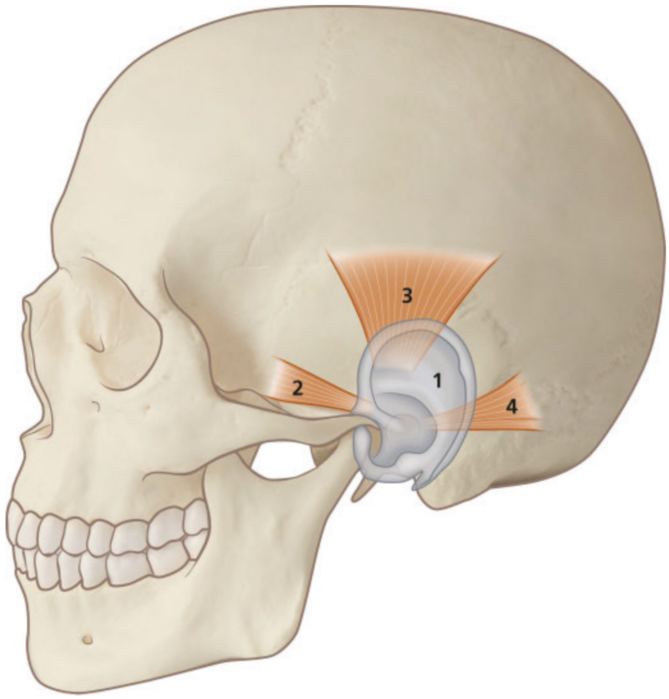

Fig. 7 Cartilage and muscles of ear: 1 = cartilage of ear; 2 = anterior auricular; 3 = superior auricular; 4 = posterior auricular

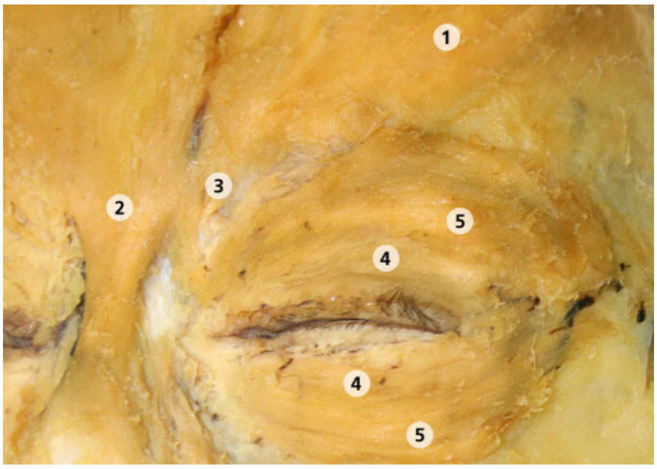

Fig. 8 Cadaveric dissection of the mimetic muscles of the fronto-orbital region (formalin-fixated head): 1 = frontalis; 2 = procerus; 3 = depressor supercilii; 4 = palpebral part of orbicularis oculi; 5 = orbital part of orbicularis oculi

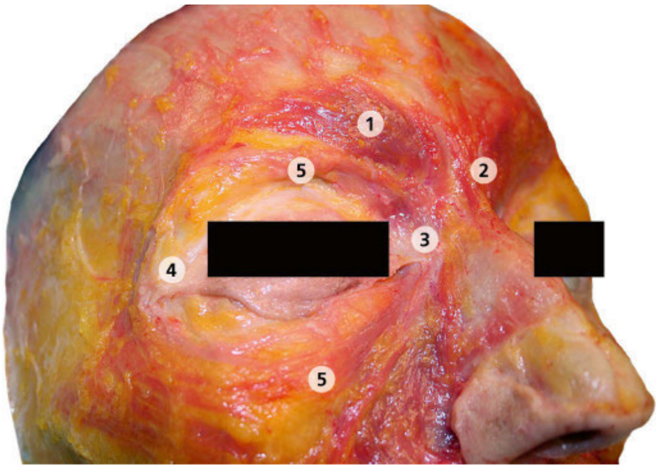

Fig. 10 Dissected periorbital mimetic muscles in a fresh cadaveric head: 1 = corrugator supercilii; 2 = procerus; 3 = medial canthal tendon; 4 = lateral canthal tendon; 5 = orbital part of orbicularis oculi

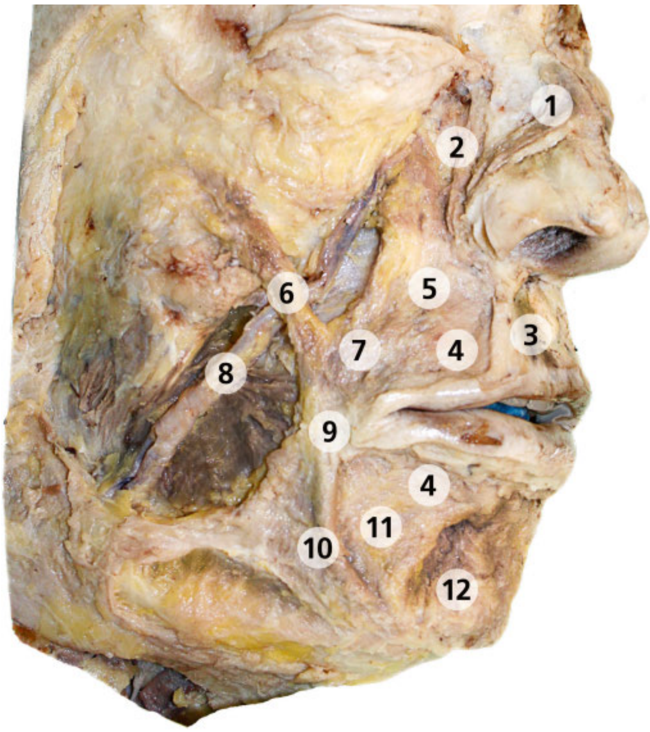

Fig. 9 Lateral view of dissected mimetic musculature of midface and lower face in a formalin-fixated cadaveric head: 1 = nasalis; 2 = levator labii superioris alaeque nasi; 3 = depressor septi nasi; 4 = orbicularis oris; 5 = levator labii superioris; 6 = zygomaticus major; 7 = levator anguli oris; 8 = facial vein; 9 = modiolus; 10 = depressor anguli oris; 11 = depressor labii inferioris; 12 = mentalis

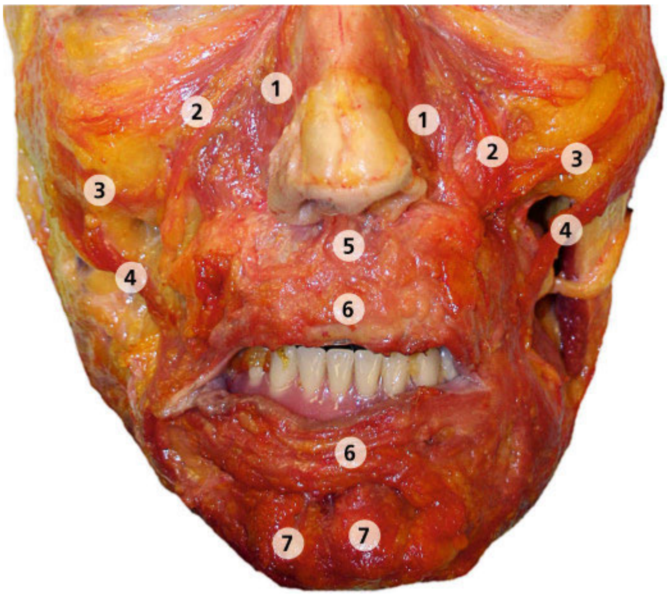

Fig. 11 Anterior view of facial muscles in a fresh cadaveric head: 1 = medial part of levator labii superioris alaeque nasi; 2 = lateral part of levator labii superioris alaeque nasi; 3 = zygomaticus minor; 4 = zygomaticus major; 5 = depressor septi nasi; 6 = orbicularis oris; 7 = mentalis

provided information from 30 articles including 721 hemifaces (Hwang et al. 2017a). Most frequently, the CSM originated from the medial supraorbital rim and ran superolaterally. In 28% of the articles, two bellies were discriminated (oblique and transverse heads). The length of the muscle ranged from 38 to 53 mm. The CSM mostly inserted to the middle of the eyebrow. Blending of the CSM with the frontalis and/or orbicularis oculi was a frequent finding. The main function of the CSM was depressing and pulling the eyebrow medially (Hwang et al. 2017a).

The depressor supercilii muscle overlies the CSM and the medial head of the orbital portion of the orbicularis oculi (Cook et al. 2001). The depressor supercilii originates from the frontal process of the os maxilla and inserts in the skin of the medial portion of the eyebrow. Thus, it also actively depresses the medial part of the eyebrow.

Eyes

The orbicularis oculi muscle encircling the external opening of the orbital cavity has two portions. The outer and larger portion is the orbital division overlying the bony orbital margins whereas the inner and smaller palpebral portion is located within the eyelids (Shams et al. 2013). The orbicularis oculi muscle originates from the bony surface to the medial canthus and from the medial canthal tendon. The fibers of the orbicularis oculi form a complete ellipse around the eye to terminate below the points of origin, but also along the inferomedial rim of the orbital cavity (Hwang et al. 2015). The orbicularis oculi muscle exhibits multiple muscular connections with the surrounding musculature (Park et al. 2011). The palpebral portion closes the eyelids while the orbital portion produces the force-

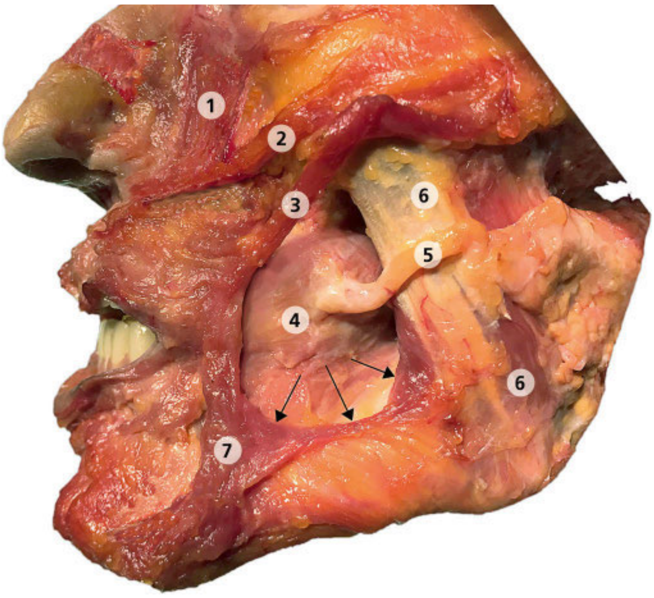

Fig. 12 Lateral view of dissected facial muscles in a fresh cadaveric head: 1 = levator labii superioris alaeque nasi; 2 = zygomaticus minor; 3 = zygomaticus major; 4 = buccinator; 5 = parotid duct; 6 = masseter; 7 = depressor anguli oris. Arrows point at the pars modiolaris of the platysma.

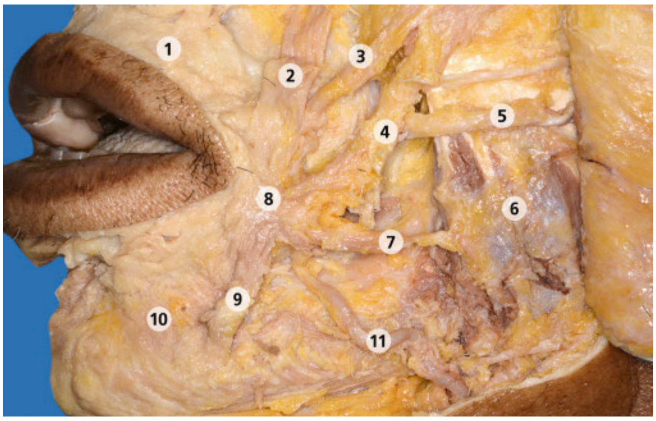

Fig. 13 Lateral view of dissected facial muscles in a formalin-fixated cadaveric head: 1 = orbicularis oris; 2 = levator anguli oris; 3 = zygomaticus minor; 4 = zygomaticus major; 5 = parotid duct; 6 = masseter; 7 = risorius; 8 = modiolus; 9 = depressor anguli oris; 10 = depressor labii inferioris; 11 = facial artery

ful eye closure (Shams et al. 2013). Hence, the orbicularis oculi is considered the eye sphincter.

Costin et al. (2014) assessed the dimensions of the orbicularis oculi in 20 fresh-frozen Caucasian cadavers (average age 74 years), i.e., the extent of the muscle relative to the orbital rim. Supraorbitally, laterally and inferiorly, the width of the orbicularis oculi was 1.4 cm, 2.5 cm and 1.2 cm, respectively. Men showed significantly larger average superior and lateral muscle extent than women.

Nose

The muscles of the nose include the nasalis, the depressor septi nasi (DSN), and the levator labii superioris alaeque nasi (LLSAN) muscles. The LLSAN originates from the medial canthal tendon and from the periosteum of the nasofrontal process of the maxilla (Konschake & Fritsch 2014). The LLSAN has two portions with the medial slip inserting into the nasal wings and the lateral slip inserting into the upper lip. The thin and flat nasalis muscle originates from the maxilla and ascends anteriorly to the dorsum of the nose (Hur et al. 2010a). The nasalis muscle narrows the nostrils and compresses the nasal vestibule while the LLSAN elevates the nasal wings (dilator of nasal openings). The DSN arises from the incisive fossae of the maxilla and/or from the orbicularis oris muscle. It ascends towards the septum to insert in the medial crura of the lower lateral cartilages (Sinno et al. 2015). The DSN pulls the nasal tip downwards.

Lips

The main muscle (and also the main component) of the lips is the orbicularis oris muscle (OOM). This muscle encircles the oral fissure (rostral opening of mouth), thus closes the lips when activated. Full activation of the muscle will purse the lips. Fibers of different perioral muscles blend with those of the orbicularis oris, or insert in the "modiolus", a tendinous structure located lateral to the commissure of the lips (Al-Hoqail & Abdel Meguid 2009).

Upper lip muscles include the zygomaticus major and minor (see below), the levator labii superioris (LLS), the levator labii superioris alaeque nasi (LLSAN), as well as the levator anguli oris (LAO). The different levator muscles pull the upper lip and the corner of the mouth upwards, while the zygomatic muscles have a diagonal action (see below). The LLS is a rectangular muscle originating from the infraorbital rim and converging into the upper lip between the lateral slip of the LLSAN and the zygomaticus minor. The LLS elevates and everts the upper lip (Hur et al. 2010b). Recent research has shown that deep fibers of the LLS attach to the vestibular skin of the nasal vestibule, thus widening the nostril when activated (Hur et al. 2010b). The LLSAN is a slim long muscle with two bellies (see section "Nose"). The medial belly converges to the nasal wing whereas the lateral belly inserts in the upper lip medial to the LLS. The LLSAN is the only muscle to pull the upper lip superomedially (HUR et al. 2010a).

The muscles of the lower lip include the depressor labii inferioris (DLI) and the depressor anguli oris (DAO). Both muscles pull the lower lip and the corner of the mouth downwards. The DLI courses upwards from the buccal cortex below the canine to the lower lip. The DLI is located medially and deep to the DAO. The latter has a triangular, fan shape with a long, linear origin from the inferior mandibular border lateral to the chin. The DAO runs superficially to the DLI towards the angle of the mouth and converges into the modiolus but also interlaces with adjacent muscles (Hur et al. 2008; Choi et al. 2014). The medial or lateral borders of the DAO also form the labiomandibular fold that increases with age. Recently, Hur et al. (2014) described medial fibers of the DAO passing deep to the DLI and often intermingling with fibers of the incisivus labii inferioris (ILI). The ILI has been described as an accessory muscle to the OOM (Hur et al. 2011, 2013). The ILI arises from the incisive fossa lateral to the mentalis muscle and courses laterally upwards to blend with the OOM and/or the buccinator. The ILI draws the corner of the lips medialwards.

According to Olszewski et al. (2009), the muscles of the lips can be divided into two classes, the muscles of dilatation and the muscles of constriction. The constrictor of the mouth is the pars labialis orbicularis oris. The dilatators of the mouth are distributed into two layers: superficial and deep. The superficial layer contains seven muscles: LLSAN, LLS, zygomaticus minor and major, risorius, DAO, and platysma, while the deep layer contains four muscles: LAO, buccinator, DLI, and mentalis (Olszewski et al. 2009).

Chin

The paired mentalis muscle is the muscle of the chin. It is the only elevator of the lower lip and it provides the major vertical support for the lower lip (Hur et al. 2013).

The mentalis muscles originate from the incisive fossae that are located below the anterior mandibular teeth. The site of origin corresponds with the labiomental fold. The fibers of the mentalis descend inferiorly to attach to the skin of the chin. The medial fibers of the two muscle bellies may cross to the contralateral side forming a dome-shaped chin prominence and may increase the rigidity of the chin (Hur et al. 2013). The lateral fibers of the mentalis muscle may intermingle with the DLI and the upper fibers with the orbicularis oris (Hur et al. 2013).

Temple region

The anterior portions of the temporalis muscles contribute to the facial parts of the temples. The temporalis muscles belong to the masticatory muscles and are innervated by the mandibular nerve (CN V3). The temporalis muscle originates from the temporal lines of the parietal bone and inserts into the coronoid process but also to the anterosuperior margin of the mandibular ramus. The muscle can be easily palpated in the temporal region when patients clench their teeth. The temporalis muscle is covered by the deep temporalis fascia which is separated from the superficial temporalis fascia by loose areolar tissue (Shams et al. 2013).

Cheeks

The muscles of the upper cheek include the zygomaticus major and zygomaticus minor. Both muscles originate from the outer surface of the zygomatic bone. They run anteroinferiorly towards the angle of the mouth and the upper lip, respectively. Upon contraction, they pull the upper lip up- and backwards (laughing). The zygomaticus minor arises from the lateral surface of the zygomatic bone posterior to the zygomaticomaxillary suture (Youn et al. 2012). The zygomaticus minor is located immediately below the orbicularis oculi muscle, often blending with its lateral fibers. It runs forward and downward to insert in the upper lip. The zygomaticus major originates at the lateral zygoma and attaches to the angle of the mouth. Occasionally, the two zygomaticus muscles cannot be distinguished upon cadaveric dissection (Youn et al. 2012), or the zygomaticus minor is absent (D'Andrea & Barbaix 2006).

The zygomaticus major may show separation in its lower portion (double or bifid zygomaticus major) (Pessa et al. 1998a; Hu et al. 2008). Pessa et al. (1998a) described such variability in 34% of dissected cadaver heads. While the superior bundle inserted above the corner of the mouth, the inferior bundle inserted into the modiolus, but occasionally also presented a dermal attachment. The latter might create the formation of cheek "dimples" upon smiling due to tethering the overlying skin (Pessa et al. 1998a). Hu et al. (2008) reported division of the zygomaticus major into two parts at the level of the buccal fat pad in 40%. While the superior band demonstrated the "normal" course, the lower muscular band ran more inferiorly and mostly blended with the DAO or risorius muscles.

Some authors have referred to a malar muscle, a muscular band originating posterior to the orbicularis oculi muscle and running obliquely, anteroinferiorly to terminate in the cheek region (Park et al. 2011).

Within the middle portion of the cheek lye the buccinator and risorius muscles. The buccinator is a relatively broad muscle and is activated, for example, when blowing the cheeks. The buccinator originates from the pterygomandibular raphe but also from bone surfaces of the posterior maxilla and mandible (although the expression of the pterygomandibular raphe is highly variable or completely absent; Shimada & Gasser 1989a). The buccinator extends forward to the corner of the mouth and its fibers may blend with those of the orbicularis oris or may cross the midline to merge with contralateral fibers. D'Andrea & Barbaix (2006) distinguished four muscle bands of the buccinator. The fourth and most inferior band (found in 85% of the cadaveric specimens) ran continuously from one side to the other and was always located superior to the mental foramina.

The risorius is a narrow muscle overlying the buccinator. It originates from the fascia of the masseter muscle and runs horizontally forward to the corner of the mouth, joining the DAO (Kim et al. 2015). In a dissection study of 46 hemifacial cadaveric specimens, the risorius originated in 59% from the external aspect of the superficial musculoaponeurotic system (SMAS) anterior or superficial to the masseter (Bae et al. 2014). The risorius muscle may often be absent (Pessa et al. 1998b; D'Andrea & Barbaix 2006). In a dissection study of 50 embalmed cadaveric heads, the risorius was only observed in 6% (Pessa et al. 1998b).

The muscle of the lower portion of the cheek is the platysma located immediately below the skin. It arises from the thoracic fascia overlying the pectoralis major and deltoid muscles. After ascending over the clavicle and lateral neck, the platysma crosses the inferior mandibular border to attach in the skin of the lower cheek or to blend with the lower perioral muscles (Hwang et al. 2017b). Hur et al. (2015) reported blending of the lateral deep slip of the platysma muscle into the buccinator muscle in 41%. The blending site was located inferolateral to the modiolus. Activation of the platysma mostly tenses the skin over the inferior mandibular border and/or draws the lips inferoposteriorly.

The masseter muscle contributes to the facial contour of the posterior cheek. It belongs to the masticatory muscles and, consequently, is not innervated by the facial nerve but rather by the mandibular nerve (CN V3). The masseter originates from the zygomatic bone (and arch). It inserts at the lower lateral portion and inferior margin of the mandibular ramus. The masseter is a powerful muscle and the main muscle for mouth closure. The region of the insertion is a frequent site for masseteric reduction surgery (Ahn et al. 2004).

Ears/auricles

Three small (extrinsic) muscles are located anterior, superior and posterior to the auricle, and pull the ear forward, upward, and backward, respectively. The anterior auricular muscle arises from the zygomatic arch and attaches to the spina of the helix. The superior auricular muscle originates from the epicranial aponeurosis and inserts along the inner surface of the triangular fossa of the auricle. The posterior auricular muscle arises from the mastoid and attaches along the internal aspect of the auricular concha (Yotsuyanagi et al. 2015).

Fasciae and fat compartments of the face

Generally, fasciae enclose individual muscles or groups of muscles, sometimes with other anatomical structures. Consequently, the human body is divided into layers by fasciae and, additionally, is partitioned into several compartments enclosed by

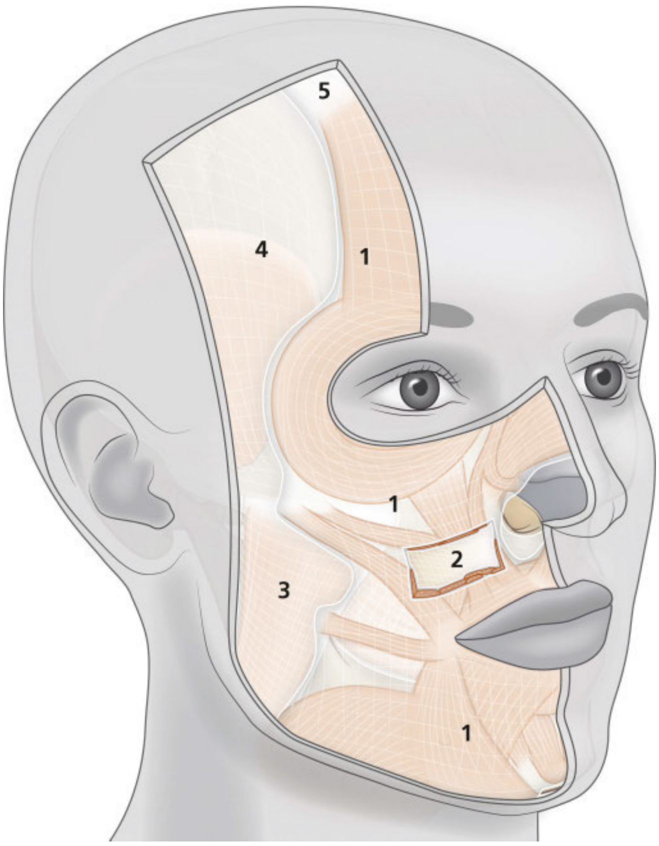

Fig. 14 Illustration of the superficial and deep fasciae of the face: 1 = superficial fascia (SMAS) investing the mimetic musculature (except buccinator); 2 = deep facial fascia; 3 = masseteric fascia; 4 = superficial temporal fascia; 5 = galea aponeurotica

fasciae (Kitamura 2017). The face commonly exhibits a superficial and a deep fascia (Kang et al. 2017) (Fig. 14).

In the middle and lower regions of the face, the superficial fascia, also known as the superficial musculoaponeurotic system (SMAS) encloses the mimetic musculature except the buccinator (Mitz & Peyronie 1976; Lindner 1986; Ghassemi et al. 2003; Macchi et al. 2010; Burrows et al. 2016). The SMAS continues superiorly to the galea aponeurotica. In the temporal region it blends with the temporoparietal fascia. Inferiorly, the SMAS invests the platysma (Shams et al. 2013). Posterolaterally, the SMAS is connected to the thick fasciae of the masseter muscle and parotid gland. Burrows et al. (2016) described the SMAS superior to the zygomatic arch as thick and robust while inferior to the arch as thin and gracile. The identification of the SMAS was a critical anatomical discovery that continues to provide a primary clinical framework for rhytidectomy ("face-lifting").

The deep fascia is located above the periosteum of the facial bones. Pessa (2016) described bilaminar membranes ("fusion zones") traveling from the deep to the superficial fascia. These fusion zones may also serve for neurovascular structures to travel along or within these membranes towards the subcutaneous tissues. The fusion zones also serve as boundaries of fat compartments in the face (Pessa 2016). Others reported that the SMAS is connected to the periosteum of underlying facial bones by fibrous "retaining ligaments", thus somewhat anchoring the soft-tissue face to the facial skeleton (Burrows et al. 2016).

According to a histotopographic study by Macchi et al. (2010), the SMAS appears in the cheek as a multilaminar structure of connective tissue, thus representing a "central tendon" for co-ordinated contraction of the mimetic musculature of the face. They further described connective laminae between the SMAS and the muscles and dermis, respectively, contributing to a three-dimensional network that modulates transmission of muscle activity to the skin (Macchi et al. 2010).

Various facial fat compartments can be observed, such as the superficial fat related to the skin with nasolabial, middle cheek superficial, and infraorbital "malar" fat compartments (Surek et al. 2015). Underlying deep midface fat compartments include medial suborbicularis oculi fat, lateral suborbicularis oculi fat, and deep medial cheek fat.

A typical fat compartment is the buccal tissue space spreading along the lateral surface of the buccinator and containing the buccal fat pad (Kitamura 2017). The bulk of suborbicularis oculi fat is located below the lateral half of the infraorbital rim but deep to the orbicularis oculi muscle (Hwang 2010). Cadaveric dissection of upper and lower lips demonstrated in all specimens fat tissue deep to the orbicularis oris. This adipose deposit was distinct from the more superficial fat of the cutaneous lips (Rohrich & Pessa 2009). The same authors described submuscular fat deep to the mentalis muscle on either side of the chin midline. The two fat compartments were not continuous and distinct from the suborbicularis oris fat (Rohrich & Pessa 2009).

Discussion

The present article reviews the musculoskeletal tissues of the face. Facial muscles and bones largely determine the individual look, and any changes (malformation, tumor, trauma, paralysis, infection) will result in a visible alteration of the face. These may have esthetic, functional but also psychological impacts on the patient. A thorough medical and dental history as well as a clinical and radiographic examination should be performed to narrow possible causes of variations and asymmetries of facial appearance.

With regard to the skeletal framework of the face, some argue that the facial skeleton cushions the brain in the event of head injuries while others claim that facial fractures act as indicators for head injuries (Patil et al. 2016). The fact is that maxillofacial trauma is often associated with cranial bone fractures, intracranial injuries and/or brain concussion (Abosadegh et al. 2017).

The facial muscles represent the functional matrix of the underlying bones of the facial skeleton (D'Andrea & Barbaix 2006). The mimetic muscles are grouped mainly around the orifices of the face. Thus, it is often argued that their primary function is to act as sphincters and dilators of those facial orifices, and that the function of facial expression has developed secondarily (Hur et al. 2010a). For example, the orbicularis oculi has a critical function in protecting the cornea through voluntary and reflex eyelid closure. Additionally, the lacrimal pump function of the eyelids acts to propel the tears to the medial canthus for entering the lacrimal drainage system (Shams et al. 2013).

Facial muscles may show structural variability with regard to size and shape, but also with regard to topography and occurrence (Shimada & Gasser 1989b; Hu et al. 2008). Some muscles may be absent (zygomaticus minor, risorius) while others show great morphological variations (zygomaticus major, buccinator). A number of muscles of the mimetic musculature are infrequently observed and described: depressor supercilii muscle, malar muscle, and incisivus labii inferioris muscle (Park et al. 2011; Hur et al. 2013). A typical feature of the facial musculature is that muscular fibers of adjacent muscles often interlace and blend with each other. These connecting fascicles from superficial to deeper muscles or to functionally opposing muscles enable synergistic actions, as evidenced by EMG, or altered functions depending upon which muscles are linked (Hur et al. 2015).

A clinically relevant issue is the occasional inadvertent anesthesia of the facial nerve (following a mandibular block) resulting in hemifacial paralysis (Bell's palsy) (von Arx & Lozanoff 2017). The latter may show an immediate onset after local anesthesia due to injection close to the facial nerve, or may commence hours (or even days) later because of ischemia of the facial nerve or reactivation of neurotropic viruses.

Cutaneous insertions of the muscles of facial expression on the upper third of the face are responsible for forehead and glabellar skin lines, and orbital crow's feet (Abramo et al. 2016). These authors also demonstrated that skin lines exhibited in voluntary contraction of the upper third of the face in patients showed the same patterns of the skin lines observed in cadavers (expression of muscle activity throughout life).

Pessa et al. (1998b) dissected 50 embalmed cadaveric heads to study any correlation of the midfacial muscles and the nasolabial fold. However, statistical analysis of the different muscular patterns failed to demonstrate any relationship. The authors concluded that other dynamic processes might determine how the nasolabial crease forms with age. For example, volume loss of fat of facial compartments is gaining support as a mechanism of aging (Rohrich & Pessa 2009). Actually, as the face ages, descent and deflation of fat compartments along with ligamentous attenuation are observed and result in deep folds, wrinkles, prominent jowling, and loss of malar projection (Surek et al. 2015).

For esthetic surgery of the face ("facial rejuvenation"), thorough knowledge of the facial musculature, fascial layers and how they relate to one another is key. During face-lifting (rhytidectomy; rhytis [Greek] = wrinkle), the SMAS is surgically manipulated by tightening and suspending the facial muscles through various flap dissections and surgical approaches (Bae et al. 2014). Cervicofacial fasciae play also an important role in the spread and final location of primary intraoral infections. Thus, knowledge of the fasciae is important for proper understanding and treatment since fasciae direct but also limit the range of such infections (Lindner 1986).

Transplantation of the face has become a viable clinical option for patients suffering from extreme disfigurement (Siemionow et al. 2009). The theoretical basis for this surgical intervention postulates that the face exists as an organ, i.e., complimentary set of tissues that perform an integrated and specific function (Siemionow et al. 2008). The facial muscles appear to conform to this definition. It has long been recognized that the muscles of facial expression innervated by CN VII lack proprioceptive receptors while the contiguous muscles of mastication that are innervated by CN V contain proprioceptors (Baumel 1974). Thus, facial muscle positioning during expression likely relies on tight coordination between CN V and CN VII implying specific integration patterns among muscles derived from different pharyngeal arch precursors (Michailovici et al. 2015). The uniqueness of the primary unipolar sensory neurons of the mesencephalic nucleus of CN V is likely reflective of this unique integration of the muscles of the face. Knowledge of this interconnectedness is particularly important to surgically repair damaged muscles of facial expression and to ensure that the patient retains proper facial expression postoperatively (Cobo et al. 2017).

Acknowledgement
The authors thank Bernadette Rawyler, medical illustrator, School of Dental Medicine, University of Bern, Bern, Switzerland, for the illustrations. The authors acknowledge the generous donation of the anatomical materials by anonymous individuals in the Willed Body Program, the University of Hawai'i John A. Burns School of Medicine, Honolulu, HI, USA.

Conflict of interest
The authors declare that there are no conflicts of interest related to this review.

Zusammenfassung
Die vorliegende Arbeit bietet eine Literaturübersicht bezüglich der muskulären und skelettalen Strukturen des Gesichtes. Muskeln und Skelett des Gesichtes bestimmen das individuelle Aussehen und die Mimik. Lähmungen, Asymmetrien oder andere Veränderungen im Gesicht müssen vom Zahnarzt erkannt werden, um evtl. verursachende dentoalveoläre Pathologien, Missbildungen oder Traumata auszuschliessen.

Die Gesichtsknochen sind Teil des vorderen Schädels (Viszerokranium). Das Os frontale bildet die Stirn und hat gelegentlich eine leichte Erhebung (Glabella) zwischen den Augenbrauen. Das Os frontale bildet auch den oberen Rand der Augenhöhle. Die Nase hat sowohl knöcherne (oben) wie auch knorpelige Anteile (unten). Das Os maxilla ist der Hauptknochen des Mittelgesichtes und stützt mit dem Zahnfortsatz (Processus alveolaris) die Oberlippe. Das Os maxilla bildet zudem den medialen und unteren Orbitarand wie auch die laterale und untere Begrenzung der Apertura nasalis. Das Os zygomaticum (Jochbein) ist die knöcherne Grundlage für den oberen Wangenbereich und die Mandibula für den unteren Wangenbereich. Im Schläfenbereich findet sich das Os temporale. Die Ohrmuschel wird von einer einzigen Knorpelstruktur gebildet, die verschiedene Erhebungen (Helix, Tragus) wie auch Einziehungen (Cavum conchae) aufweist.

Die Muskulatur des Gesichtes umfasst die zahlreichen mimetischen Muskeln wie auch zwei mastikatorische Muskeln (M. masseter und M. temporalis). Die mimetischen Muskeln, die alle vom N. facialis (7. Gehirnnerv) innerviert werden, haben ihren Ursprung von Knochenoberflächen des Viszerokraniums und ziehen zur darüberliegenden Gesichtshaut oder vermischen sich mit anderen Muskeln.

Die Gesichtsmuskeln im Stirnbereich umfassen M. frontalis, M. procerus, M. depressor supercilii und M. corrugator supercilii. Im Augenbrauenbereich finden sich häufig Vermischungen der Fasern dieser vier Muskeln. Der Ringmuskel der Augen, M. orbicularis oris, besteht aus zwei Teilen: der äusseren Pars orbitalis, die auf dem knöchernen Rand des Orbitaeinganges liegt, sowie der inneren Pars papebralis, die innerhalb der Augenlider lokalisiert ist.

Die Muskulatur der Nase besteht aus M. nasalis, M. depressor septi nasi sowie M. levator labii superioris alaeque nasi. Letzterer Muskel besteht aus zwei Anteilen, wobei nur der mediale Anteil zur Nase zieht. Dieser Muskel zieht die Nasenflügel nach oben, während der M. nasalis als Antagonist die Nasenöffnungen verengt. Der M. depressor septi nasi zieht von der Fossa incisiva zum vorderen Nasenseptum und zieht die Nasenspitze nach unten.

Der M. orbicularis oris bildet die muskuläre Grundstruktur der Lippen und wirkt als Sphinkter. Sowohl der M. levator labii superioris alaeque nasi (mit seinem lateralen Anteil) wie auch der M. levator labii superioris ziehen zur Oberlippe und heben diese an. Der oberflächlich liegende M. zygomaticus minor verläuft schräg vom Jochbein nach vorne unten zur Oberlippe und zieht diese nach hinten-oben. Der tiefer liegende M. levator anguli oris zieht zum Mundwinkel, wo sich eine Sehnenplatte (Modiolus) findet. In diese strahlen weitere Muskeln ein, beispielsweise der M. depressor anguli oris von unten und der M. risorius von hinten. Der M. depressor labii inferioris zieht die Unterlippe nach unten und der M. mentalis ist der Stützmuskel der Unterlippe.

Der Hauptmuskel der Wange ist der relativ breite M. buccinator, der von der Raphe pterygomandibularis nach vorne zum Mundwinkel zieht und teilweise in den M. orbicularis oris einstrahlt. Im unteren Wangenbereich findet sich unmittelbar unter der Haut das Platysma. Im Gesicht sind zudem eine oberflächliche und eine tiefe Faszie vorhanden, die Kompartimente mit Muskeln und anderen Weichgeweben (z.B. Fettgewebe) bilden.

Résumé

Le présent travail fournit une revue de la littérature sur les structures musculaires et squelettiques du visage. Les muscles et le squelette du visage déterminent l'apparence individuelle et l'expression faciale. Les paralysies, les asymétries ou d'autres modifications du visage doivent être reconnues par le dentiste afin d'exclure les pathologies dento-alvéolaires, les malformations ou les traumatismes.

Les os du visage font partie du crâne antérieur (visco-crâne). L'os frontal forme le front et a parfois une légère éminence (glabelle) entre les sourcils. L'os frontal forme également le bord supérieur des orbites. Le nez a des parties osseuses (supérieures) et cartilagineuses (inférieures). L'os maxillaire est l'os principal du tiers médian de la face et soutient la lèvre supérieure avec le processus dentaire (processus alvéolaire). Le maxillaire forme aussi les parties médiales et inférieures des orbites ainsi que les limites latérales et inférieures de l'ouverture nasale. L'os zygomatique est la base osseuse de la partie supérieure de la joue et la mandibule celle de la partie inférieure. Dans la région temporale se trouve l'os temporal. Le pavillon de l'oreille est formé par une seule structure cartilagineuse qui a diverses éminences (hélice, tragus), ainsi que des invaginations (cavité de la conque).

La musculature du visage comprend les nombreux muscles de la mimique ainsi que deux muscles masticateurs (muscles masséter et temporal). Les muscles de la mimique qui sont tous innervés par le nerf facial (7e nerf crânien) proviennent des surfaces osseuses du visco-crâne et tirent vers la peau sus-jacente du visage, ou se mélangent avec d'autres muscles.

Les muscles faciaux dans la région du front comprennent le muscle frontal, le muscle procerus, les muscles abaisseurs du sourcil et corrugateurs du sourcil. Dans la zone des sourcils, il y a souvent des mélanges des fibres de ces quatre muscles. Le muscle circulaire de l'œil, muscle orbiculaire de l'œil, se compose de deux parties: la partie orbitaire externe qui se trouve sur le rebord orbital osseux, ainsi que la partie palpébrale interne qui est située dans les paupières.

La musculature du nez est composée du muscle nasal, du muscle abaisseur du septum nasal, ainsi que du muscle releveur de la lèvre supérieure et de l'aile du nez. Ce dernier muscle se compose de deux parties, de sorte que seule la partie médiale tire vers le nez. Ce muscle tire les ailes nasales vers le haut, tandis que le muscle nasal en tant qu'antagoniste rétrécit les ouvertures nasales. L'abaisseur du septum nasal tire de la fosse incisive vers la cloison nasale antérieure et tire la pointe du nez vers le bas.

Le muscle orbiculaire de la bouche forme la structure musculaire de base des lèvres et agit comme un sphincter. Le muscle releveur de la lèvre supérieure et de l'aile du nez (avec sa partie latérale) et le muscle releveur de la lèvre supérieure s'étendent jusqu'à la lèvre supérieure et la soulèvent. Le muscle grand zygomatique, superficiel, s'étend obliquement de la pommette vers le bas vers la lèvre supérieure et tire cette dernière vers l'arrière et le haut. Le muscle élévateur de l'angle de la bouche, profond, s'insère à l'angle de la bouche où se trouve une plaque tendineuse (modiolus). Dans celle-ci rayonnent des muscles supplémentaires, par exemple le muscle abaisseur de l'angle de la bouche d'en bas, et le risorius de l'arrière. L'abaisseur de la lèvre inférieure tire la lèvre inférieure vers le bas, et le muscle mentonnier est le muscle de soutien de la lèvre inférieure.

Le muscle majeur de la joue est le relativement large muscle buccinateur qui s'étend du raphé ptérygomandibulaire vers l'avant jusqu'à la commissure de la bouche et qui irradie en partie dans le muscle orbiculaire de la bouche. Dans la partie inférieure de la joue, le platysma se trouve directement sous la peau. Sur le visage, il y a aussi des fascias, l'un superficiel et l'autre profond, qui forment des compartiments avec les muscles et d'autres tissus.

References

Abosadegh M M, Ab Rahman S, Saddki N: Association of traumatic head injuries and maxillofacial fractures: a retrospective study. Dent Traumatol 33: 369–374 (2017)

Abramo A C, Do Amaral T P, Lessio B P, De Lima G A: Anatomy of forehead, glabellar, nasal and orbital muscles, and their correlation with distinctive patterns of skin lines on the upper third of the face: reviewing concepts. Aesthetic Plast Surg 40: 962–971 (2016)

Ahn J, Horn C, Blitzer A: Botulinum toxin for masseter reduction in Asian patients. Arch Facial Plast Surg 6: 188–191 (2004)

Al-Hoqail R A, Abdel Meguid E M: An anatomical and analytical study of the modiolus: enlightening its relevance to plastic surgery. Aesthetic Plast Surg 33: 147–152 (2009)

Bae J H, Lee J H, Youn K H, Hur M S, Hu K S, Tansatit T, Kim H J: Surgical consideration of the anatomic origin of the risorius in relation to facial planes. Aesthetic Surg J 34: 43–49 (2014)

Baumel J J: Trigeminal-facial nerve communications and their function in facial muscle innervation and reinnervation Arch Otolaryngol 99: 34–44 (1974)

Burrows A M, Rogers-Vizena C R, Li L, Mendelson B: The mobility of the human face: more than just the musculature. Anat Rec (Hoboken) 299: 1779–1788 (2016)

Choi Y J, Kim J S, Gil Y C, Phetudom T, Kim H J, Tansatit T, Hu K S: Anatomical considerations regarding the location and boundary of the depressor anguli oris muscle with reference to botulinum toxin injection. Plast Reconstr Surg 134: 917–921 (2014)

Cobo J L, Sole-Magdalena A, Menendez I, de Vicente J C, Vega J A: Connections between the facial and trigeminal nerves: Anatomical basis for facial muscle proprioception. JPRAS Open12: 9–18 (2017)

Cook B E, Lucarelli M J, Lemke B N: Depressor supercilii muscle: anatomy, histology, and cosmetic implications. Ophthal Plast Reconstr Surg 17: 404–411 (2001)

Costin B R, Sakolsatayadorn N, McNutt S A, Rubinstein T J, Trichonas G, Rocha K M, McClintic J I, Huang L, McBride J M, Perry J D: Dimensions and anatomic variations of the orbicularis oculi muscle in nonpreserved, fresh-frozen human cadavers. Ophthal Plast Reconstr Surg 30: 198–200 (2014)

D'Andrea E, Barbaix E: Anatomic research on the perioral muscles, functional matrix of the maxillary and mandibular bones. Surg Radiol Anat 28: 261–266 (2006)

Daniel R K, Landon B: Endoscopic forehead lift: anatomic basis. Aesthetic Surg J 17: 97–104 (1997)

Dechow P C, Wang Q: Development, structure, and function of the zygomatic bones: what is new and why do we care? Anat Rec 299: 1611–1615 (2016)

Diamond M, Wartmann C T, Tubbs R S, Shoja M M, Cohen-Gadol A A, Loukas M: Peripheral facial nerve communications and their clinical implications. Clin Anat 24: 10–18 (2011)

Ghassemi A, Prescher A, Riediger D, Axer H: Anatomy of the SMAS revisited. Aesthetic Plast Surg 27: 258–264 (2003)

Hafezi F, Naghibzadeh B, Nouhi A H: Applied anatomy of the nasal lower lateral cartilage: a new finding. Aesthetic Plast Surg 34: 244–248 (2010)

Hu K S, Jin G C, Youn K H, Kwak H H, Koh K S, Fontaine C, Kim H J: An anatomic study of the bifid zygomaticus major muscle. J Craniofac Surg 19: 534–536 (2008)

Hur M S, Hu K S, Cho J Y, Kwak H H, Song W C, Koh K S, Lorente M, Kim H J: Topography and location of the depressor anguli oris muscle with a reference to the mental foramen. Surg Radiol Anat 30: 403–407 (2008)

Hur M S, Hu K S, Park J T, Youn K H, Kim H J: New anatomical insight of the levator labii superioris alaeque nasi and the transverse part of the nasalis. Surg Radiol Anat 32: 753–756 (2010a)

Hur M S, Youn K H, Hu K S, Song W C, Koh K S, Fontaine C, Kim H J: New anatomic considerations on the levator labii superioris related with the nasal ala. J Craniofac Surg 21: 258–260 (2010b)

Hur M S, Hu K S, Kwak H H, Lee K S, Kim H J: Inferior bundle (fourth band) of the buccinator and the incisivus labii inferioris muscle. J Craniofac Surg 22: 289–292 (2011)

Hur M S, Kim H J, Choi B Y, Hu K S, Kim H J, Lee K S: Morphology of the mentalis muscle and its relationship with the orbicularis oris and incisivus labii inferioris muscles. J Craniofac Surg 24: 602–604 (2013)

Hur M S, Kim H J, Lee K S: An anatomic study of the medial fibers of depressor anguli oris muscle passing deep to the depressor labii inferioris muscle. J Craniofac Surg 25: 614–616 (2014)

Hur M S, Bae J H, Kim H J, Lee H B, Lee K S: Blending of the lateral deep slip of the platysma muscle into the buccinator muscle. Surg Radiol Anat 37: 931–934 (2015)

Hur M S: Anatomical relationships of the procerus with the nasal ala and the nasal muscles: transverse part of nasalis and levator labii superioris alaeque nasi. Surg Radiol Anat 39: 865–869 (2017)

Hwang K: Surgical anatomy of the lower eyelid relating to lower blepharoplasty. Anat Cell Biol 43: 15–24 (2010)

Hwang K, Kim H J, Kim H, Kim D J, Hwang S W: Origin of the lower orbicularis oculi muscle in relation to the nasojugal groove. J Craniofac Surg 26: 1389–1393 (2015)

Hwang K, Lee J H, Lim H J: Anatomy of the corrugator muscle. J Craniofac Surg 28: 524–527 (2017a)

Hwang K, Kim J Y, Lim H J: Anatomy of the platysma muscle. J Craniofac Surg 28: 539–542 (2017b)

Kang H G, Youn K H, Kim I B, Nam Y S: Bilayered structure of the superficial facial fascia. Aesthet Surg J 37: 627–636 (2017)

Kim H S, Oh J H, Choi D Y, Lee J G, Choi J H, Hu K S, Kim H J, Yang H M: Three-dimensional courses of zygomaticofacial and zygomaticotemporal canals using micro-computed tomography in Korean. J Craniofac Surg 24: 1565–1568 (2013)

Kim H S, Pae C, Bae J H, Hu K S, Chang B M, Tansatit T, Kim H J: An anatomical study of the risorius in Asians and its insertion at the modiolus. Surg Radiol Anat 37: 147–151 (2015)

Kitamura S: Anatomy of the fasciae and fascial spaces of the maxillofacial and the anterior neck regions. Anat Sci Int 93: 1–13 (2018)

Konschake M, Fritsch H: Anatomical mapping of the nasal muscles and application to cosmetic surgery. Clin Anat 27: 1178–1184 (2014)

Kwak H H, Park H D, Youn K H, Hu K S, Koh K S, Han S H, Kim H J: Branching patterns of the facial nerve and its communication with the auriculotemporal nerve. Surg Radiol Anat 26: 494–500 (2004)

Lindner H H: The anatomy of the fasciae of the head and neck with particular reference to the spread and treatment of intraoral infections (Ludwig's) that have progressed into adjacent fascial spaces. Ann Surg 204: 705–714 (1986)

Loukas M, Owens D G, Tubbs R S, Spentzouris G, Elochukwu A, Jordan R: Zygomaticofacial, zygomaticoorbital and zygomaticotemporal foramina: anatomical study. Anat Sci Int 83: 77–82 (2008)

Macchi V, Tiengo C, Porzionato A, Stecco C, Vigato E, Parenti A, Azzena B, Weiglein A, Mazzoleni F, de Caro R: Histotopographic study of the fibroadipose connective cheek system. Cells Tissues Organs 191: 47–56 (2010)

Michailovici I, Eigler T, Tzahor E: Craniofacial muscle development. Curr Top Dev Biol 115: 3–30 (2015)

Mitz V, Peyronie M: The superficial musculo-aponeurotic system (SMAS) in the parotid and cheek area. Plast Reconstr Surg 58: 80–88 (1976)

Olszewski R, Liu Y, Duprez T, Xu T M, Reychler H: Three-dimensional appearance of the lips muscles with three-dimensional isotropic MRI: in vivo study. Int J Comput Assist Radiol Surg 4: 349–352 (2009)

Park J T, Youn K H, Hur M S, Hu K S, Kim H J, Kim H J: Malaris muscle, the lateral muscular band of orbicularis oculi muscle. J Craniofac Surg 22: 659–662 (2011)

Patil S G, Patil B S, Joshi U, Allurkar S, Japatti S, Munnang A: The facial skeleton: armor to the brain. Indian J Dent 7: 116–120 (2016)

Pessa J E, Zadoo V P, Garza P A, Adrian E K, Dewitt A I, Garza J R: Double or bifid zygomaticus major muscle: anatomy, incidence, and clinical correlation. Clin Anat 11: 310–313 (1998a)

Pessa J E, Zadoo V P, Adrian E K, Yuan C H, Aydelotte J, Garza J R: Variability of the midfacial muscles: analysis of 50 hemifacial cadaver dissections. Plast Reconstr Surg 102: 1888–1893 (1998b)

Pessa J E: SMAS fusion zones determine the subfascial and subcutaneous anatomy of the human face: fascial spaces, fat compartments, and models of facial aging. Aesthetic Surg J 36: 515–526 (2016)

Pinar Y, Govsa F, Ozer M A, Ertam I: Anatomocosmetic implication rules of the corrugator supercilii muscle for youthful eye appearance. Surg Radiol Anat 38: 1045–1051 (2016)

Rohrich R J, Pessa J E: The anatomy and clinical implications of perioral submuscular fat. Plast Reconstr Surg 124: 266–271 (2009)

Shams P N, Ortiz-Pérez S, Joshi N: Clinical anatomy of the periocular region. Facial Plast Surg 29: 255–263 (2013)

Shimada K, Gasser R F: Morphology of the pterygomandibular raphe in human fetuses and adults. Anat Rec 224: 117–122 (1989a)

Shimada K, Gasser R F: Variations in the facial muscles at the angle of the mouth. Clin Anat 2: 129–134 (1989b)

Siemionow M, Sonmez E: Face as an organ. Ann Plast Surg 61: 345–352 (2008)

Siemionow M, Papay F, Alam D, Bernard S, Djohan R, Gordon C, Hendrickson M, Lohman R, Eghtesad B, Coffman K, Kodish E, Paradis C, Avery R, Fung J: Near-total human face transplantation for a severely disfigured patient in the USA. Lancet 374: 203–209 (2009)

Sinno S, Chang J B, Saadeh P B, Lee M R: Anatomy and surgical treatment of the depressor septi nasi muscle: a systematic review. Plast Reconstr Surg 135: e838–e848 (2015)

Surek C C, Beut J, Stephens R, Jelks G, Lamb J: Pertinent anatomy and analysis for midface volumizing procedures. Plast Reconstr Surg 135: e818–e829 (2015)

Trikeriotis D, Paravalou E, Diamantopoulos P, Nikolaou D: Anterior mandible canal communications: a potential portal of entry for tumor spread. Dentomaxillofac Radiol 37: 125–129 (2008)

von Arx T, Lozanoff S: Clinical relevance of the parotid gland and the facial nerve. In: von Arx T, Lozanoff S (eds): Clinical Oral Anatomy – A comprehensive Review for Dental Practitioners and Researchers. 1st edition, Springer International Publishing, Switzerland, p 43 (2017)

von Arx T, Abdelkarim A Z, Lozanoff S: The face – a neurosensory perspective: a literature review. Swiss Dent J 127: 1066–1075 (2017)

von Arx T, Tamura K, Oba Y, Lozanoff S: The face – a vascular perspective: a literature review. Swiss Dent J 128: 382–392 (2018)

Yotsuyanagi T, Yamauchi M, Yamashita K, Sugai A, Gonda A, Kitada A, Saito T, Urushidate S: Abnormality of auricular muscles in congenital auricular deformities. Plast Reconstr Surg 136: e78–e88 (2015)

Youn K H, Park J T, Park D S, Koh K S, Kim H J, Paik D J: Morphology of the zygomaticus minor and its relationship with the orbicularis oculi muscle. J Craniofac Surg 23: 546–548 (2012)