

# Facial anatomy and the application of fillers and botulinum toxin – Part I

## *Anatomia da face aplicada aos preenchedores e à toxina botulínica – Parte I*

### ABSTRACT

The use of botulinum toxin and cutaneous filling techniques has encouraged a renewed interest in the study of facial anatomy. An assessment of the influence of facial structures in the aging process requires an in-depth understanding of the constitution of the epidermis, dermis and subcutaneous tissue. It is also essential to study the boundaries of facial segments and bones, the musculature, vascularization, sensory and motor innervation, and the lymphatic drainage of the face. A broad understanding of facial anatomy will help perfect cutaneous filling and botulinum toxin techniques.

**Keywords:** anatomy; botulinum toxin type A; injections, intradermal.

### RESUMO

*O uso da toxina botulínica e das técnicas de preenchimento trouxeram novo interesse no estudo da anatomia facial. Para melhor avaliação da influência das estruturas da face no processo do envelhecimento, são necessários profundo conhecimento da constituição da epiderme, derme e tecido subcutâneo, estudo dos limites dos segmentos faciais e dos ossos da face, assim como da musculatura, vascularização, inervação sensitiva e motora e drenagem linfática da face. A visão mais ampla da anatomia da face contribuiu para aprimorar as técnicas de aplicação de preenchimento e toxina botulínica.*

**Palavras-chave:** anatomia; toxina botulínica tipo A; injeções intradérmicas.

### INTRODUCTION

The use of botulinum toxin has encouraged renewed interest, especially in the field of Dermatology, in the study of facial musculature and other anatomical areas. The study of movements and the close relationship between muscles and their effects in facial expressions has stimulated the development of new approaches, categorizations, and injection points.

Achieving natural results while maintaining some expression wrinkles is the current global trend in the use of botulinum toxin. This goal, in addition to the development of products for filling wrinkles and restoring facial volume, requires a dynamic approach in the evaluation of the aging process. There is no longer a rigid and straightforward technique or standard, and when more advanced methods are introduced, it is necessary for dermatologists to keep pace with new developments.<sup>1</sup>

The issues relevant to filling techniques are:

**a** - Anatomical areas that are more affected by bone absorption;

## Continued Medical education



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**b** - Dynamic movements of the face that displace the filler and become it visible with the action of the muscles;

**c** - Areas with natural fat;

**d** - Effects of chronological aging, gravity and patients' habits;

**e** - Importance of the vascular system (especially in the glabellar, ocular, nasal and frontal areas), due to reports of arterial occlusion, ischemia and even embolism and their severe consequences.

## SKIN ANATOMY

The epidermis is comprised of four distinct layers: 1) the stratum corneum (keratinized), which is the impermeable barrier that retains liquids; 2) the stratum granulosum; 3) the stratum spinosum, which is nourished by dermal capillary vessels; and 4) the stratum basale, where the melanocytes, Langerhans cells (with a probable role in triggering immune responses), and Merkel cells (which are linked to sensory nerve endings) are located.

The dermis, which consists of both cellular and acellular elements, is the layer that contains the collagen and elastic fibers, which are linked to the formation of wrinkles. Since it is firm, compact and not very stretchable, the dermis resists the penetration of needles. It is well vascularized and contains nerve endings, which makes intradermal injections more painful than those applied in other layers of the skin. Substances injected into the dermis produce very superficial papules that indicate the depth reached.

The eccrine (sweat) glands are present in the tegument in general, and in greater numbers in the palms, bottoms of the feet, and scalp. They have glomeruli, located in the deep dermis, which are made up of two layers: the internal (secretory), and the external (with myoepithelial cells).

The apocrine glands are located mainly in the axillae, inguinal, and perianal regions, in addition to other small areas in the tegument (linked to chronic disseminated hidradenitis suppurativa). In the apocrine glands, located in the hypodermis, the glomeruli and the myoepithelial layer are more developed than in the eccrine glands.

Located immediately beneath the dermis, the subcutaneous layer is comprised of fatty tissue, which is divided into the areolar (with vessels and nerves) and lamellar layers. Its thickness, arrangement and the presence of fasciae or cavities are extremely important when analyzing the facial aging process from a volumetric perspective.

This discussion of the anatomy of the skin is not intended to be a detailed histological study, but rather an introduction to the techniques and planes of injection of products for filling wrinkles, based on a publication by Arlette (2008).<sup>2</sup> The author reports that the dermis removed from the nasolabial fold region is 1.32 to 1.55 mm thick, the diameter of the needle usually employed to inject fillers ranges from 0.3 and 0.4 mm, and the length of the bevel ranges between 0.75 and 0.95 mm. The fact that in most cases fillers are injected beneath the dermis – even by experienced physicians – is therefore questioned. Although the technique of using different angles for the introduction of the needle in the superficial, medium or deep dermis is still recommended, these variations should be observed with millimetric precision.

## DERMIS AND SUBCUTANEOUS TISSUE

The epidermis and dermis are thicker in the forehead than in the inferior third of the face. Underneath is the subcutaneous tissue (Figure 1), the galea aponeurotica (belonging in the Superficial Musculoaponeurotic System – SMAS), the loose subaponeurotic areolar layer, and the periosteum. The injection of large volumes of fillers in the forehead does not yield satisfactory results.

The skin in the temporal region is thin, with a great amount of dense connective tissue, and the visible linear projection of the superficial temporal artery and vein. Due to these factors, vascular structures should be taken into account during the injection of fillers, with the application of delicate massage in order to prevent the product from becoming visible. The deep fat layer is dense in the temporal and periocular areas, and the temporal extension of the Bichat's deep fat pad is found in these sites. It is also necessary to describe the temporoparietal fascia and the temporal galea. Although superficial fat is scarce in the forehead, glabella and temporal regions, it is dense due to the fibrous septae. In the glabella, above the supercillii, there is also a structure called the galeal adipose pad.

The supercillii present a standard of normality, which is used when planning their intended location after the treatment of the frontal, glabellar, and periocular areas with botulinum toxin or fillers. The supercillii are located 5 to 6 cm below the hairline; the medial region is aligned with the lateral portion of the alae nasi, 1 cm above the internal corner of the eye. The lateral portion of the supercilium ends in the oblique line that links the base of the alar cartilage of the nose and the external canthus. The medial and lateral regions of the supercilium are located at the same level, aligned horizontally. In women, the supercillii should be above the supraorbital margin, arch-shaped, with their highest point at the junction of the medial and lateral thirds of the face. In men, the arch should be smaller and slightly further below the supraorbital margin.



**Figure 1 -**  
Subcutaneous  
tissue

The sub orbicular ocular fat (SOOF) is located on top of the lowest portion of the zygomatic bone and under the orbicularis muscle. It is separated from the periorbital fat by the thin orbital and malar septum. Malar fat pads, located below the orbital margin level, can result from the ptosis of the SOOF. When fillers are injected in the nasojugal fold or laterally to it, it is important to be cautious with the medial and lateral palpebral ligaments (Figure 2). The lateral ligament acts as a barrier, preventing the dispersion of the filler beyond it. Therefore, fillers should be administered in small amounts in the inferolateral orbital fold (in the submuscular plane) followed by massage to assist dispersion.

The perforating musculocutaneous vessels are located in the malar prominence. The malar fat is located alongside the nasolabial fold. Ptosis and pseudohermiation of the SOOF and orbital fat occur as part of the aging process. The sagging of the medial portion of the cheek causes the accumulation of fat in the anterior and inferior portions, and the decrease of fat in the lateral and superior portions. Such anatomic alterations result in deep nasolabial folds, multiple folds in the cheek when smiling and a depression in the submalar area. The vector that pulls the face downwards also causes a skeletonised appearance in the malar region, which has prompted the need for filling in this area.

The fat in the cheek, in the nasolabial fold and in the mandible is dense. The malar fat pad in the malar region is divided into the jugal and mandibular portions. Their deep components are located between the muscular fasciae. The Bichat's fat pad is located anteriorly to the masseter and more deeply in relation to the posterior fascia in the buccal region. The location of those structures, as well as the shape of the face, should be considered when planning the injection of fillers aimed at lifting the malar and medial regions. It is necessary to avoid creating artificial results in the patient, as if a prosthesis had been implanted. In the parotideomasseteric region, the skin adheres closely to the risorius and platysma muscle fibers. The facial nerve branches (Figure 3) and the parotid gland duct (Figure 4) are located posteriorly to the SMAS and anteriorly to the masseter and the buccal fat. When treating the parotid region, it is

important to bear in mind that the duct is located below the line linking the angle of the mouth to the tragus, due to descriptions of traumatic fistulas. The parotidomasseteric fascia where the risorius muscle originates also involves the parotid gland and the masseter muscle.<sup>3-6</sup>

The nose is comprised of skin, cartilage and bone structures, supported by conjunctive tissue and ligaments that keep them joined. In the lower third of the nose, the skin is thicker and adhered, and is thinner and slightly more movable in the upper two-thirds. This joined structure can receive careful injections of fillers, given that migration of the material is very rare.

The skin of the lips can be described as thick and juxtaposed to the muscular layer, with the thin and delicate red area (vermilion), composed of transitional epithelium between skin and mucous membrane. The subcutaneous of the lateral region of the lips influences the adhesion of the skin and mucous membrane to the muscles. The lack of additional support in that level and excessive muscular movement can lead to the appearance of wrinkles. Due to the adherence of the skin and mucous



Figure 3 – Facial nerve

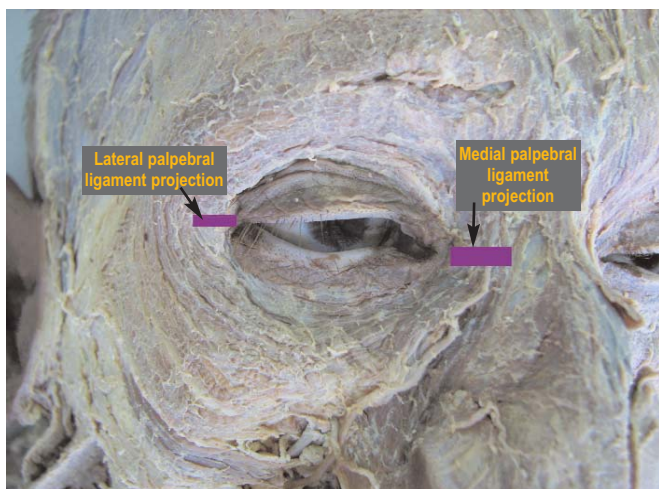


Figure 2 – Palpebral ligaments



Figure 4 – Parotid duct



membrane to the muscles, injecting products to treat perpendicular wrinkles does not present good results. It does not produce focused corrections appropriately, and can alter the shape of the upper lip as a whole. Moreover, the large amount of vessels, combined with their tortuous arrangement, easily leads to the formation of hematomas.

The chin region's skin is thin, with the depressor muscle of the angle of mouth and the platysma located in the projection of the labiomarginal fold (Figure 5). The thin skin partially explains why inadequate injections of botulinum toxin in this area lead to undesired asymmetries. In the mentonian area, the superficial adipose tissue to SMAS is firmly attached to the dermis through fibrous septa, closely adhering the deep tissues to the skin at that level. Due to this high degree of adherence, products injected in this area are not easily displaced when massaged; this makes it a good choice for supraperiosteal injection in the reconstruction of the chin and mandible with fillers.

Preauricular folds and earlobes are also current targets for fillings. Fillers are used not only to increase firmness and provide structure to such areas, but also with to provide tissular resistance and reduce the recurrence of clefts after the surgical reconstruction of the orifice. The lobule is comprised of thin skin, medium thickness dermis and subcutaneous tissue. The vessels are located in the subcutaneous tissue, and are very thin and well distributed.

**BOUNDARIES OF THE FACIAL SEGMENTS**

The upper third of the face has as borders the imaginary line drawn from the tragus up to the external canthus then surrounding the inferior lid margin and delimiting the nasal root. The middle third extends down to an imaginary line from the tragus to the corners of the mouth, including the upper lip. The lower third includes the lower lip down to the mandibular border (Figure 6).

The temporal region is delimited anteriorly by the temporal portion of the zygomatic bone, posteriorly by the supramas-

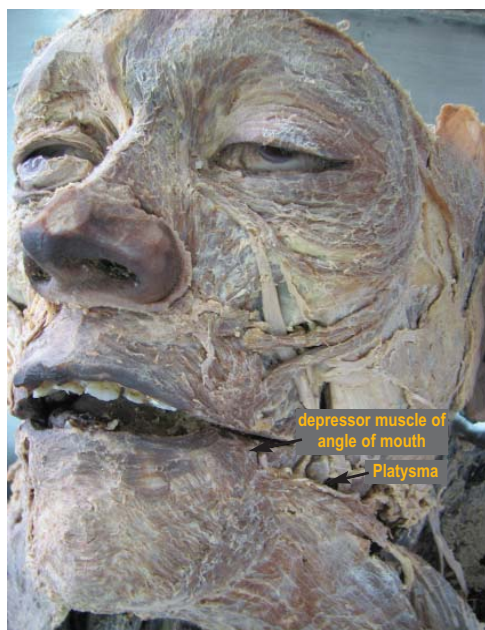
teroid crest, superiorly by the superior temporal line and inferiorly by the horizontal plane that crosses the zygomatic arch. The skin is on the surface, while the frontal, sphenoid, parietal and temporal bones are in the deeper plane. The temporal area's lateral or superficial boundary is the temporal fascia, which covers the superficial bundles of the temporal muscle. The latter corresponds to the medial or deep boundary of the temporal area. It contains adipose tissue and communicates directly with the masticator and buccal space.

The orbicular region can be divided into lateral and medium canthal, superior and inferior lacrimal, and superior and inferior eyelid portions.

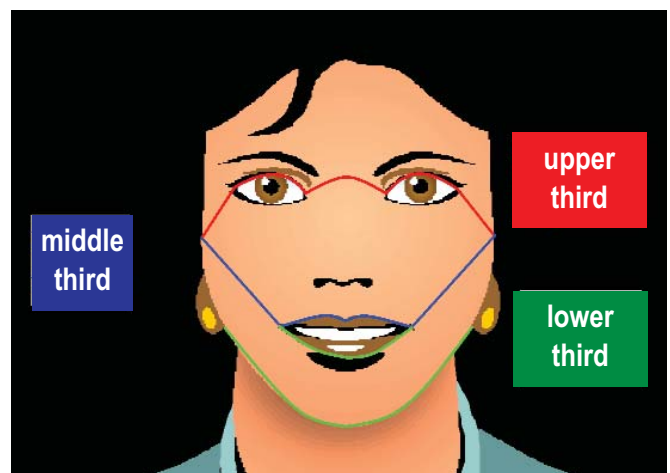
The infratemporal region is located between the infratemporal face of the greater wing of the sphenoid bone (superior boundary) and the plane that touches the base of the mandible (inferior boundary). The anterior boundaries of the infraorbital and zygomatic regions and the cheek are the external nose and the nasolabial and labiomarginal folds; the posterior boundary is the masseter muscle's anterior margin; the superior boundary is the infraorbital margin; the inferior boundary is the base of the mandible. The boundaries of the superior cheek are the malar complex and the mandible (inferiorly). Its shape and size are determined by the parotid gland, the musculature and buccal fat. Below the muscles of the infraorbital, zygomatic, and cheek region, a mucous membrane covers the bones of the region and spans the space between the superior and inferior vestibular fornicies of the mouth and the periosteum.

The ideal location of the malar region's prominence is 10 mm laterally and 15 mm below the external corner of the eye. Deficiencies in these measurements result in the prolongation of the maxilla and insufficient projection of the middle third of the face. The submalar triangle is the inverted depressed triangular area in the middle third of the face, delimited above by the zygoma's prominence, medially by the nasolabial fold and laterally by the masseter muscle.

The parotideomasseteric region's anterior boundary is the anterior margin of the masseter muscle; the posterior boundaries are the mastoid process and the sternocleidomastoid mus-



**Figure 5** – Facial mimicry muscles



**Figure 6** – Facial segment boundaries

cle's anterior margin. Its superior boundary is the zygomatic arch up to the external acoustic pore; its inferior boundaries are the plane that touches the base of the mandible and the mastoid process; the medial boundaries are the styloid process (posteriorly) and the pharynx's lateral wall (anteriorly).

The superior boundary of the nasal region is located between the two superciliary arches, the inferior boundary is located in a horizontal line tangent to the nasal base, and the lateral boundary is located between the medial angle of the eye and the nasolabial fold. The nasal region is divided into: the base (where the nostrils are), which corresponds to the base of an imaginary pyramid; the root (the upper part of the nose), corresponding to the apex of the pyramid; the apex (the nasal tip); the dorsum (the portion between the lateral right and left faces of the nose); and the ala nasi. The measure of the nasolabial angle is roughly 90-100° in men and 100-110° in women.

The superior boundary of the lips corresponds to the base of the nose; the lateral boundary, to the nasolabial fold; the inferior boundary, to the mentolabial fold; and the lateral boundary, to the labiomarginal fold. The lips extend past the vermilion (red area of the mouth) and include the adjacent skin. Therefore, this anatomical unit has extensions longer than that of the nose and shorter than that of the mentum. The structure of the perfect lip includes a white line (or a transition line), visible between the mucous membrane and the skin; a medium-sized tubercle; a "V" shaped cupid's bow (concavity in the base of the philtrum); the vermilion; and the ascending line in the buccal commissure. The ideal relationship (or "golden ratio") between the upper and lower lips is 1:1.618. The philtrum is an important reference point, since the upper lip's cutaneous central point is enhanced by the two vertical columns of the philtrum. Excessively deep labiomental and nasolabial lines result in an aged appearance.

The superior boundary of the mentonian region is the mentolabial fold, the inferior boundary is the base of the mandible, and the lateral boundary is the labiomarginal fold. The middle lateral zone extends from the posterior mentonian foramen to the oblique line of the horizontal body of the mandible. The posterior lateral zone is delimited by the posterior half of the body, including the angle and the first 2 to 4 cm of the mandible's ascending branch. The area below the chin is called the submentonian region and is located between the platysmal bands and above the cervicomental angle.

### **ANATOMY OF THE FACIAL BONES**

The cranial cavity, where the brain and the meninges – its covering membranes – are located, are delimited by the frontal, ethmoid, sphenoid, occipital, temporal and parietal bones (the last two are paired). The bones of the face include the frontal bone and various pairs of bones: the nasal, lacrimal, zygomatic, maxillae and mandible. The vomer is unpaired, with the paired bones – the palatines and the inferior nasal conchae – located more deeply. The bones that support deep grafts and skull fillings are located in the nasal (nasal bone), malar (zygomatic bones and maxillae), and mentonian (gnathic and mental protuberance) regions (Figure 7).

### **FOREHEAD**

The forehead is comprised of the frontal bone, which connects with the nasal bones in its caudal portion on each side of the midline. The nasion (Figure 7B) is the intersection of the frontal bone with the two nasal bones; above this area, between the supercilia, is the glabellar region. Originating in the glabella, the superciliary arch extends laterally on both sides.

### **ORBITS**

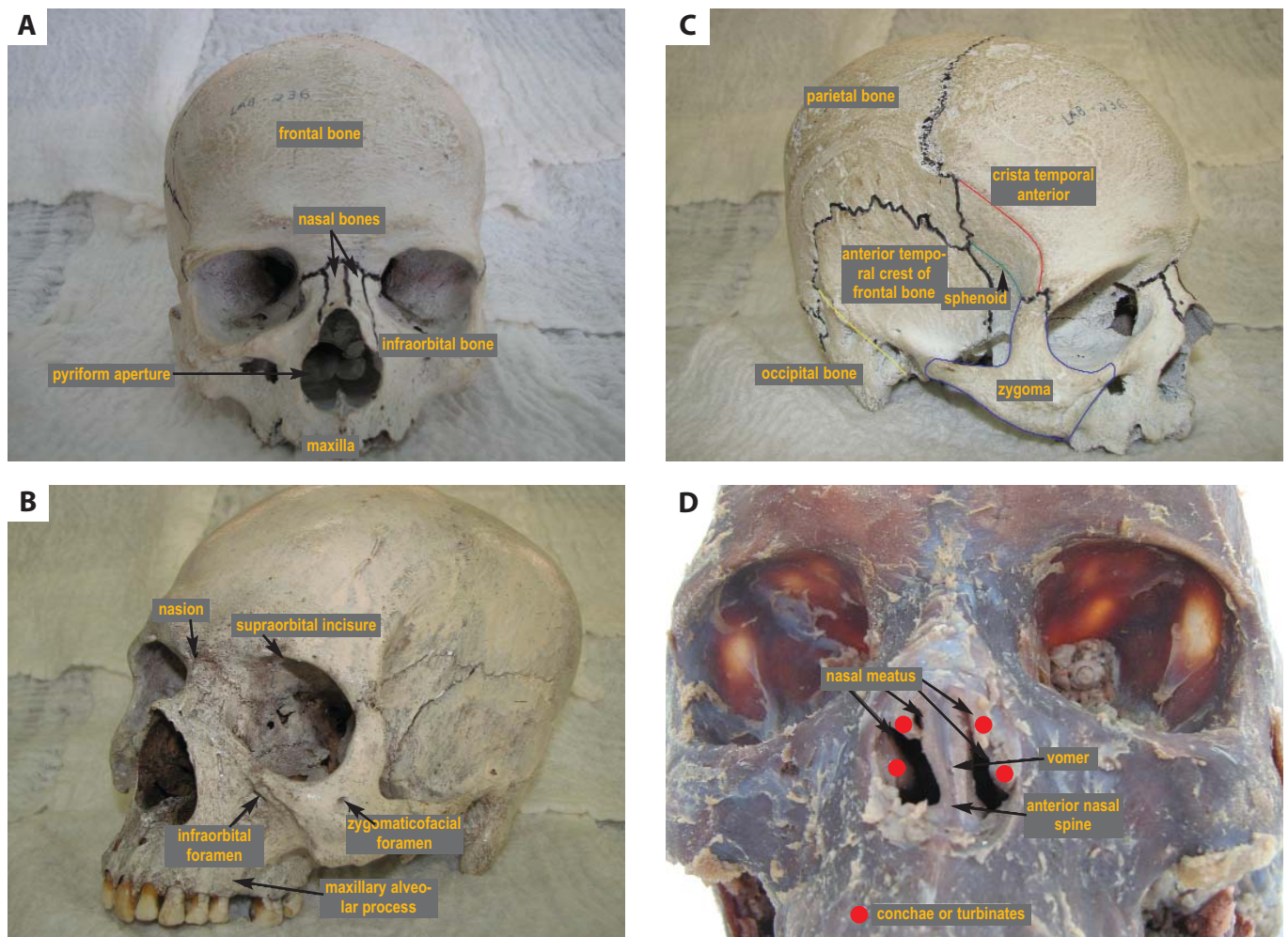
The eyes are located in the orbital bone cavities that are subdivided into superior, lateral, inferior and medial borders. The frontal bone forms the superior or supraorbital margin. The supraorbital foramen, which houses the supraorbital nerve and vessels, is located in the medial portion, with its border crossed by the supratrochlear nerve and vessels. The supraorbital margin ends laterally in the zygomatic process of the frontal bone, with the frontal bone directed posteriorly in each of the supraorbital borders. The lateral margin is formed by the zygomatic and frontal bones, while the inferior margin is constituted by the maxilla and the zygomatic. The maxillae, lacrimal and frontal bones constitute the medial margin of the orbit. Below the inferior margin of the orbit, in the mid-pupillary line, the maxilla presents an opening, the infraorbital foramen (Figure 7B), for the passage of the infraorbital nerve and artery.

### **PROMINENCE OF THE FACE**

The malar (zygomatic) bone, located in the inferior and lateral margin of the orbit, resting on the maxilla, constitutes the prominence of the face. It is constituted of lateral and orbital surfaces – which together form the lateral wall of the orbit – and the temporal surface, which is located in the temporal fossa. The frontal process connects to the zygomatic process of the frontal bone, while the temporal process connects to the zygomatic process of the temporal bone. In its lateral portion, the zygomatic bone is perforated by the small zygomaticofacial foramen (Figure 7B) for the passage of the zygomaticofacial nerve. Anesthetizing that site facilitates the filling and sculpting of the malar region.

### **EXTERNAL NASAL STRUCTURE**

The nose's bone structure is constituted of the nasal bones and the maxillae, ending anteriorly with the pyriform aperture (Figure 7A). The soft tissues of the nose are formed by a cartilage structure (medial and lateral) that is linked to the pyriform aperture by fibrous tissue. The junction of the medial and lateral cartilages is called the dome. The shape of the nasal tip depends on those structures, and its support depends on the skin, ligaments and cartilage as a whole. The superior border of the nasal orifices is formed by the nasal bones, while the lateral and inferior borders are formed by the maxillae. The nasal cavities are separated by the nasal septum. The anterior portion of the septum is formed by cartilage, while the posterior portion is formed by the ethmoid and vomer bones. In the lateral walls of the nasal cavity there are three or four curved bone plaques called nasal conchae (or turbinates), with the space below each



Figures 7 (A, B, C, D) – Bone structure of the cranium

of them defined as a nasal meatus. In the median region, the inferior border of the pyriform aperture presents an anterior nasal spine. The nasal bones connect superiorly with the frontal bone, and laterally with the frontal processes of the maxillae, with their inferior borders attached to the nasal cartilages.

**MAXILLAE**

The two maxillae form the upper jaw. Their growth is responsible for the vertical elongation of the face between the ages of 6 and 12 years. In the aging process, the bone absorption in that area slows; gravity and fat absorption in the malar region are the major causes of the slackened appearance of the face. The body of the maxilla contains the maxillary sinus; the zygomatic process extends laterally and connects with the zygomatic bone; the frontal process aligns upwardly and connects with the frontal bone; the palatine process is horizontal and connects to the opposite side, forming the skeleton of the palate; and the alveolar process contains the upper teeth.

The pyramidal shape of the maxillae, with a nasal surface or base, forms the lateral wall of the nasal cavity; the orbital face

consists of the floor of the orbit; the infratemporal surface forms the anterior wall of the corresponding fossa; and the anterior surface is covered by the facial muscles. At about 1 cm below the infraorbital margin, the anterior surface of the maxilla presents the infraorbital foramen (possibly multiple), which forms a passage to the infraorbital artery and the nerve – the location of which we use as a reference for a longitudinal line coincident with the pupil, for the anesthesia through nerve blocks of the complete inferior region of the maxilla, up to the lateral angle of the mouth (Figure 7B).

The upper teeth are implanted in the alveolar processes of the maxillae. The intermaxillary suture is the union point between the two maxillae, and the portion of the maxillae that supports the incisor teeth is called the premaxilla.

**MANDIBLE**

The mandible, or lower maxilla, is the largest and strongest bone of the face (Figure 8). The lower teeth are located in the alveolar area of the mandible. Below the second premolar tooth is the mental foramen, an orifice that allows the passage of the



mental nerve and vessels. Also located in that site is an imaginary line that crosses the pupil and serves as a reference for the anaesthetic blockade of the lower lip and part of the chin. The mandible's body is "U"-shaped and comprised of a pair of branches. The junction behind and below the inferior third of the molar tooth, is described as a part of the branch or a part of the body. That region is marked by the angle of the mandible, which has  $125^\circ$  (range  $110\text{--}140^\circ$ ). Its greatest prominence, aligned laterally, is known as the gonion. The symphysis of the mentum is the median region of the mandible. The inferior border of the mandible is called the base, and the digastric fossa is the irregular depression located at the base or close to the symphysis. Four centimetres before the angle of the mandible, the base presents a ridge through which the facial artery passes – with its pulsation being perceptible. The insertion of the masseter muscle occurs in the smooth and even lateral surface of the branch of the mandible.

The alveolar portions of both the maxilla and the mandible suffer serious reabsorption over time, which may lead to the loss of teeth. This process is clearly reflected in the aging of the lower third of the face. The mandible is reabsorbed as a whole, with its portions becoming thinner and narrower, reinforcing the slackening appearance, resulting in the loss of facial contour and the formation of jowls. Although these regions attract great interest, it is important to note that the orbit, temporal region, sinus areas, and the zygomatic arch also change with the years, as can be observed in Figures 9 and 10, which show the skull and mandible, respectively, at different ages.

### TEMPORAL

The temporal bone comprises the squama temporalis, the tympanic part, the styloid, the mastoid, and the petrous portions. The squamous and mastoid portions are more relevant to this article, and are therefore described in more detail. In the squamous portion, the parietal bone connects inferiorly with the squamous part of the temporalis bone (squamous suture). From the squamous portion of the temporalis bone, the zygomatic process (zygoma) is projected anteriorly, connecting to the

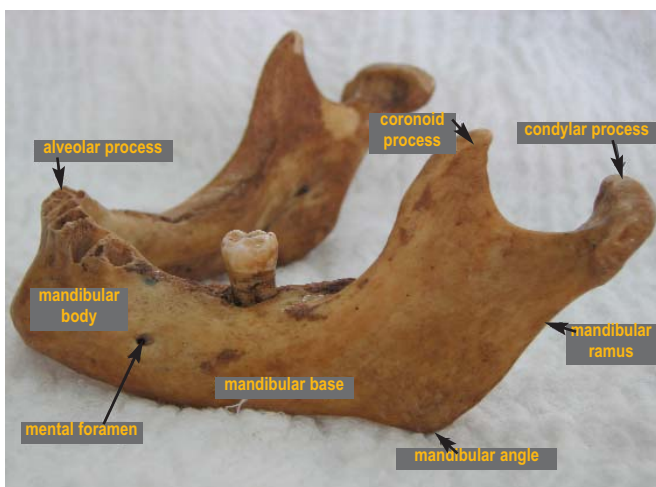


Figure 8 – Mandible structure



Figure 9 (A,B) – Craniums at different ages

zygomatic bone, thus completing the zygomatic arch. The upper border of the zygomatic arch corresponds to the lower border of the cerebral hemisphere and allows the insertion of the temporal fascia. The masseter muscle originates in the zygomatic arch's inferior border and deep surface. The temporomandibular joint's lateral ligament is inserted in the zygoma's root tubercle (inferior border of the arch). The head of the mandible is located posteriorly to the tubercle, in the mandibular fossa.

### TEMPORAL FOSSA

The temporal line (to which the temporal fascia is attached) originates in the zygomatic process of the frontal bone. It forms an arch directed posteriorly, through the frontal and parietal bones, with a variable distance from the sagittal suture. The posterior portion is attached to the supramastoid crest of the temporal bone. The temporal fossa is located between the temporal line and the zygomatic arch; this is the



**Figure 10 (A,B)** – Mandibles at different ages

site where the temporal muscle is lodged. The muscle originates on the temporal floor, which is formed by parts of the parietal and frontal bones, the greater wing of the sphenoid bone and the squamous part of the temporal bone. The site where the four bones converge is called the pterion. It is located on the anterior branch of the middle meningeal artery, which runs in the internal face of the skull. It also corresponds to the furrow that marks the brain's lateral fissure. The center of the pterion is located roughly 4 cm above the midpoint of the zygomatic arch, and at approximately the same distance behind the zygomatic process of the frontal bone.

The temporal muscle and the deep temporal vessels and nerves cross the space between the zygomatic arch and the remaining part of the skull. Through this space, the temporal fossa communicates with the infratemporal fossa located underneath. The infratemporal fossa is located behind the maxilla, the temporal fossa is medial, with its ceiling formed by the infratemporal surface of the greater wing of the sphenoid. The medial

boundary of the infratemporal fossa is the lateral plate of the pterygoid process of the sphenoid; the lateral boundary is the mandible's ramus and coronoid process. The inferior region of the temporal bone, the lateral and medial pterygoid muscles, the maxillary artery and its branches, and the venous pterygoid plexus – as well as the mandibular and maxillary nerves, and the chorda tympani – are also parts of the temporal fossa. The temporal fossa communicates with the orbit through the inferior orbital fissure, in a continuum with the pterygomaxillary fissure. In addition, its communication with the pterygomaxillary fissure provides a close relationship with the maxillary artery and nerve below the orbital apex.

Part 2 of this CME article, expected to be published in December 2010, as part of Volume 2, Number 4 of this Journal, will include the following information: a detailed description of the musculature, sensory and motor innervation, vascularization and lymphatic drainage of the face, as they apply to cosmetic procedures. ●

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