INTRODUCTION

Surgical rejuvenation of the aging face has evolved into one of the most frequently performed surgical procedures in the world. Face lifting, initially performed as a skin tightening procedure since the early 1900, has technically matured during the last quarter of the 20's century(1-2). This evolution is directly related to the scientific investigation of the facial soft tissue anatomy, resulting in a better understanding of the facial anatomic changes that occur with aging (3). A plethora of procedures has evolved during the last years that use a variety of technical approaches, having as a common goal the reconstruction of aging-related anatomic changes.

Both the public perception and the aesthetic concepts of face lifting have evolved over time. Initially, both patients and surgeons focused solely on the laxity that occurs with facial aging, attempting to tighten what was loose rather than to shape the face, hence the term face lifting (as opposed to facioplasty), a mechanical term implying a procedure whose goal is to lift what has fallen (3). Unfortunately, this mechanical approach to facial rejuvenation often produced a tight-appearing, operated-on look, the stigma of the "wind tunnel appearance" so often associated with surgical rejuvenation of the aging face (4).

Nonetheless, on the basis of better understanding of the facial soft tissue anatomy and the anatomical changes that occurs in aging, face lifting has developed into both a reconstructive procedure (whose goal is to reconstruct the anatomical changes that occur in aging) and a more artistically defined technique that attempts to enhance facial appearance while minimizing signs that a surgical procedure has been performed.

There are many treatment goals in face lifting besides simply correcting the hallmarks the aging face, including improvement of the nasolabial folds and facial jowling and correction of obliquity of cervical contour. As important as the mechanical aspects of tightening a loose, aged face are the aesthetic concepts of improving facial shape and bringing out the beauty in the face that existed during youth. To these goals, the surgeon attempting facial rejuvenation must have a thorough understanding of facial soft tissue anatomy, comprehend the anatomical changes that occur in aging to produce a change in facial shape, and understand the ideal facial shape that can be obtained for a particular patient.

History

The idea of lifting facial skin did not originally come from a surgeon, but from an elderly female Polish aristocrat who, in 1901, asked the Berlin surgeon Eugen Holländer to lift her cheeks and the corners of the mouth. She asked him to cut out the skin elliptically around the ear. It took quite a while before the patient could convince the surgeon [5]. Erich Lexer published in 1931 a remarkable textbook Die Gesamte Wiederherstellungschirurgie (The Complete Reconstructive Surgery). He stated to have operated on an aging actress, who constructed reins of rubber bands and stitching plasters to keep her facial skin tight. After years this produced overlapping excess skin, which Lexer excised with S-shaped excisions in 1906. He stated not having known that such a surgery had been performed before [6]. Jacques Joseph, also from Germany, published his first facelift surgery from 1912 in 1921 and 1928 [2, 7].

Charles Miller from the USA wrote in 1906 an article entitled "The excision of bag-like folds of skin from the region about the eyes" [8]. He published in 1907 the first textbook of facial cosmetic surgery under the title "the Correction of Featural Imperfections" [9]. Another American, Kolle, wrote in 1911 the book "Plastic and Cosmetic Surgery" [10]. He published illustrations of lower eyelid incisions to remove the loose skin.

In France, Passot was first surgeon to describe the submental excision to correct a double chin and multiple facial direct excisions in 1919 in his article "La chirurgie esthétique des rides du visage" [11]. Suzanne Noel was the first female cosmetic surgeon and she tried to emphasize the sociologic aspects of aesthetic surgery in her book "La Chirurgie Esthétic: Son Role Sociale" published in 1926 [12]. Other French pioneers in this field were Bourgouet [13] and Pires [14].

The Czech plastic surgeon Burian suggested incision lines reaching deep into temporal and retroauricular hair-covered areas which have been used for decades. He also advocated wide undermining to achieve long-lasting results [15].

After the periods of World War I and World War II which were times when the demand on plastic surgeons was predominantly in reconstructive and not in aesthetic surgery, Mayer and Swanker were the first to use the term "rhytidoplasty" in the journal Plastic and Reconstructive Surgery in 1950 [2,16]. This term would be later exchanged for rhytidectomy, which means excisions of wrinkles and folds [16]. In the following period, innovative contributions to facial rejuvenation were made by González-Ulloa [3] from Mexico, Gillies [2] from the UK, Millard [17] from the USA, and Pitanguy [18] from Brazil.

In the 1970s one went into the deeper planes of the face. Skoog of Sweden wrote in his book Plastic Surgery: "New Methods and Refinements" in 1974 [19] about the subcutaneous layer with its fascia and muscles attached at skin to be repositioned to obtain more sustainable results. Tessier of France was also a pioneer who noticed the importance of the deep structures of the face [20]. Mitz and Peyronie from France made important anatomic studies (1976) and defined the new age in facelift surgery: superficial musculo-aponeurotic system (SMAS) of the face [21].

Connell (22), Owsley (23), Lemmon, and Hamra (24), all from the USA, developed further the usage of SMAS in their clinical practice.

After the 1980s and into the 1990s, the subperiosteal plane was reached and was rearranged in order to produce rejuvenation. Ramirez (25) and Little (26), both from the USA, stepped over into the third dimension of the face by different maneuvers like skeletal augmentation, soft-tissue transplantation and reassembling and imbrications of facial structures, not only tightening and stretching of tissue, but also adding volume to the facial framework in order to beautify the face.

Since the early 1990s the subperiosteal plane with endoscopic microcameras and special endoscopic instrument has been reached. This microinvasive surgery is less traumatic. Forehead surgery and elevation of the eyebrows have experienced special advancements. Vasconez, Ramirez, and Nahai (27) are only a few of the pioneers to be mentioned.

Recently, many other authors made their contributions to the evolution of rhytidectomy (28-32), such as Mendelson from Australia, Baker and Stuzin from the USA. There has also been a trend in the last few years for less invasive surgery. To mention only a few names: Massiha from the USA, Tonnard and Verpaele from Belgium, and Saylan from Germany.

Surgical anatomy

Safe and effective surgical facial rejuvenation relies on a clear knowledge and understanding of facial anatomy. Techniques evolve and improve as the complex, layered architecture and soft tissue compartments of the face are discovered and delineated through imaging, staining techniques, and dissections both intra-operatively and in the research laboratory on cadavers (33).

To create a more youthful, natural-looking form, the surgeon endeavors to reverse some of the changes that occur due to aging. These include volumetric changes in soft tissue compartments, gravitational changes, and the attenuation of ligaments. Whether the plan of rejuvenation includes rhytidectomy, blepharoplasty, autologous fat transfer, implants, or endoscopic techniques, a sound knowledge of facial anatomy will increase the likelihood of success and reduce the incidence of undesirable results or complications.

Superficial Fat Compartments

The pioneering work of Rohrich (34), using staining techniques and cadaver dissections, has revealed a number of distinct superficial fat compartments in the face. These compartments are separated from one another by delicate fascial tissue and septae that converge where adjacent compartments meet to form retaining ligaments. The superficial fat compartments of the face comprise the following: the nasolabial fat compartment, the medial, middle, and lateral temporal- cheek "malar" fat pads, the central, middle, and lateral temporal-cheek pads in the forehead, and the superior, inferior, and lateral orbital fat pads, in addition to jowl and preplatysmal fat compartments (Figure 1).

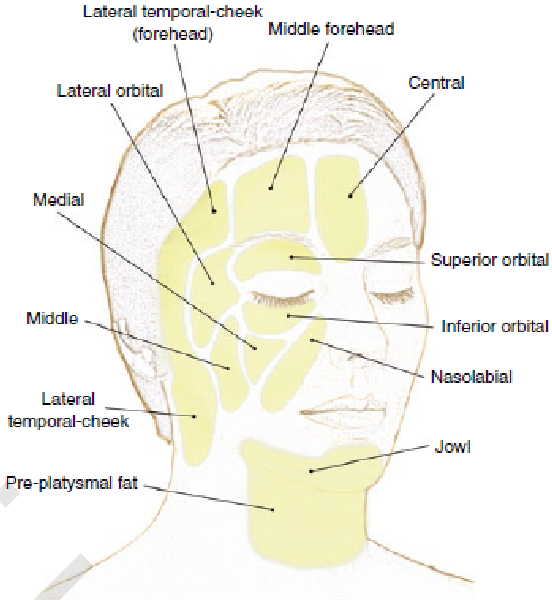

Figure (1): The superficial fat compartments of the face. (34)

Nasolabial fat lies medial to the cheek fat pad compartments and contributes to the overhang of the nasolabial fold. The orbicularis retaining ligament below the inferior orbital rim represents the superior border of the nasolabial fat compartment and the medial cheek compartment (Figure 2).

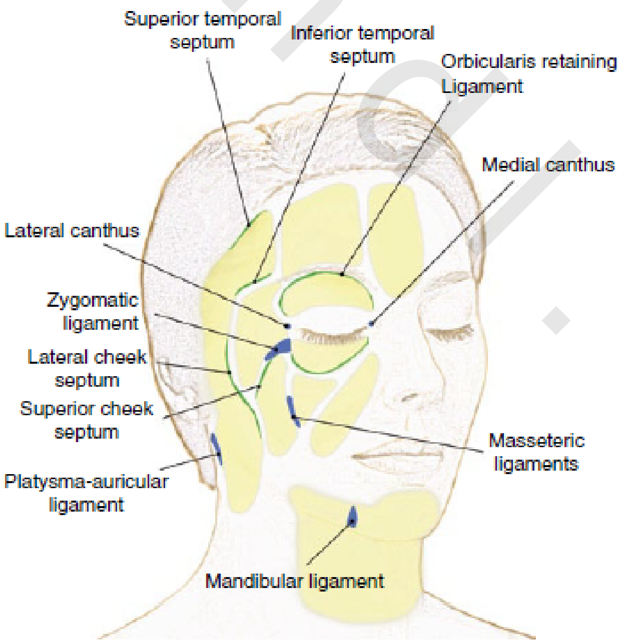

Figure (2): The Ligaments and septae between fat compartments of the face (34)

The middle cheek fat compartment lies between the medial and lateral temporal-cheek fat compartments and is bounded superiorly by a band of fascia termed the superior cheek septum. The borders of the middle cheek compartment, inferior, and lateral orbital fat pad compartments converge to form a tougher band of tissue called the zygomatic ligament (35). The condensation of connective tissue at the borders of the medial and middle fat compartments correlates with the masseteric ligaments in the same location (29).

The lateral temporal-cheek fat pads span the entire face from the forehead to the cervical area. Its anterior boundary, the lateral cheek septum, is encountered during facelift procedures with medial dissection from the preauricular incision. In the forehead, its upper and lower boundaries are identifiable as the superior and inferior temporal septa. Medial to the lateral temporal-cheek fat compartment in the forehead, the middle forehead fat pad is bounded inferiorly by the orbicularis retaining ligament and medially by the central forehead fat compartment.

Above and below the eyes, the superior and inferior orbital fat compartments lie within the perimeter of the orbicularis retaining ligament. These periorbital fat pads are separated from one another medially and laterally by the medial and lateral canthi, respectively. The lateral orbital fat compartment is the third orbital fat pad and is bounded superiorly by the inferior temporal septum and inferiorly by the superior cheek septum. The zygomaticus major muscle attaches, through fibrous septae, to overlying superficial fat compartments along its length. In the lower third of the face, the jowl fat compartment adheres to the depressor anguli oris muscle and is bounded medially by the depressor labii and inferiorly by bands of the platysma muscle.

The compartmentalized anatomy of the superficial subcutaneous fat of the face has implications in the aging process. Volume loss appears to occur at different rates in different compartments, leading to irregularities in facial contour and loss of the seamless, smooth transitions between the convexities and concavities of the face associated with youthfulness and beauty (29).

Superficial Musculoaponeurotic System (SMAS)

In 1974, Mitz and Peyronie published their description of a fibrofatty superficial facial fascia they called the superficial musculoaponeurotic system (SMAS) (21). This system or network of collagen fibers, elastic fibers, and fat cells connects the mimetic muscles to the overlying dermis and plays an important functional role in facial expression. The SMAS is central to most current facelift techniques where it is usually dissected, mobilized, and redraped. In simple terms, the SMAS can be considered as a sheet of tissue that extends from the neck (platysma) into the face (SMAS proper), temporal area (superficial temporal fascia), and medially beyond the temporal crest into the forehead (galea aponeurotica).

However, the precise anatomy of the SMAS, regional variations, and even the existence of the SMAS are debated (36). Ghassemi (37) describes two variations of SMAS architecture. Type I SMAS consists of a network of small fibrous septae that traverse perpendicularly between fat lobules to the dermis and deeply to the facial muscles or periosteum. This variation exists in the forehead, parotid, zygomatic, and infraorbital areas. Type II SMAS consists of a dense mesh of collagen, elastic, and muscle fibers and is found medial to the nasolabial fold, in the upper and lower lips. Although extremely thin, type II SMAS binds the facial muscles around the mouth to the overlying skin and has an important role in transmitting complex movements during animation.

Over the parotid gland, the SMAS is relatively thick. Further medially, it thins considerably making it difficult to dissect. In the lower face, the SMAS covers the facial nerve branches as well as the sensory nerves. Dissection superficial to the SMAS in this region protects facial nerve branches [38]. Above the zygomatic arch, the SMAS exists as the superficial temporal fascia, which splits to enclose the temporal branch of the facial nerve and the intermediate temporal fat pad. Dissection in this area should proceed deep to the superficial temporal fascia, on the deep temporal fascia, to avoid nerve injury. Although considered as one "system" or plane, the surgeon should be mindful of the regional differences in SMAS anatomy from superior to inferior and lateral to medial.

Retaining Ligaments

True retaining ligaments are easily identifiable structures that connect the dermis to the underlying periosteum. False retaining ligaments are more diffuse condensations of fibrous tissue that connect superficial and deep facial fasciae [39] (Figure 3).

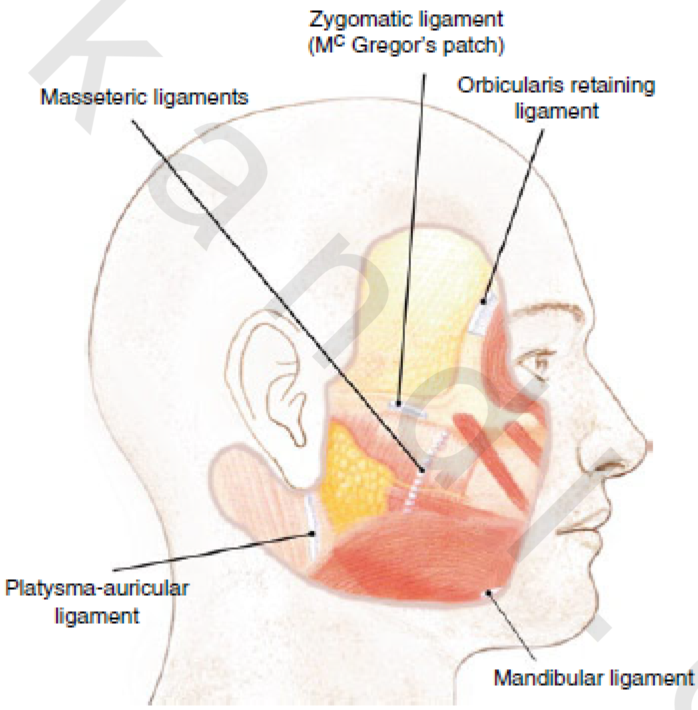

Figure (3): The retaining ligaments of the face. [41]

The zygomatic ligament (McGregor's patch) is a true ligament that connects the inferior border of the zygomatic arch to the dermis and is found just posterior to the origin of the zygomaticus minor muscle [35]. Other true ligaments include the lateral orbital thickening on the superolateral orbital rim that arises as a thickening of the orbicularis retaining ligament, and the mandibular retaining ligament. The latter connects the periosteum of the mandible just medial to the origin of depressor anguli oris to the overlying dermis. This attachment gives rise to the labiomandibular fold just anterior to the jowl.

The masseteric ligaments are false retaining ligaments that arise from the anterior border of masseter and insert into the SMAS and overlying dermis of the cheek. With aging, these ligaments attenuate, the SMAS over the masseter becomes ptotic, and this leads to the formation of jowls [40]. Below the lobule of the ear, the platysma-auricular ligament represents a condensation of fibrous tissue where the lateral temporal cheek fat compartment meets the postauricular fat compartment.

During facial rejuvenation procedures, true and false retaining ligaments are encountered and often released in order to mobilize and redrape tissue planes. Extra care should be taken when releasing ligaments as important facial nerve branches are intimately related to ligaments such as the zygomatic and mandibular retaining ligaments.

Mimetic Muscles

The muscles of facial expression are thin, flat muscles that act either as sphincters of facial orifices, as dilators, or as elevators and depressors of the eyebrows and mouth. Frontalis, corrugator supercilii, depressor supercilii, procerus, and orbicularis oculi represent the periorbital facial muscles. The perioral muscles include the levator muscles, zygomaticus major and minor, risorius, orbicularis oris, depressor anguli oris, depressor labii, and mentalis. The nasal group includes compressor naris, dilator naris, and depressor septi. In the neck, the platysma muscle lies superficially and extends into the lower face [33] (Figure 4).

The frontalis represents the anterior belly of the occipitofrontalis muscle and is the main elevator of the brows. It arises from the epicranial aponeurosis and passes forward over the forehead to insert into fibers of the orbicularis oculi, corrugators, and dermis over the brows. Contraction raises the eyebrows and causes horizontal furrows over the forehead. Frontalis receives innervations from the temporal branch of the facial nerve.

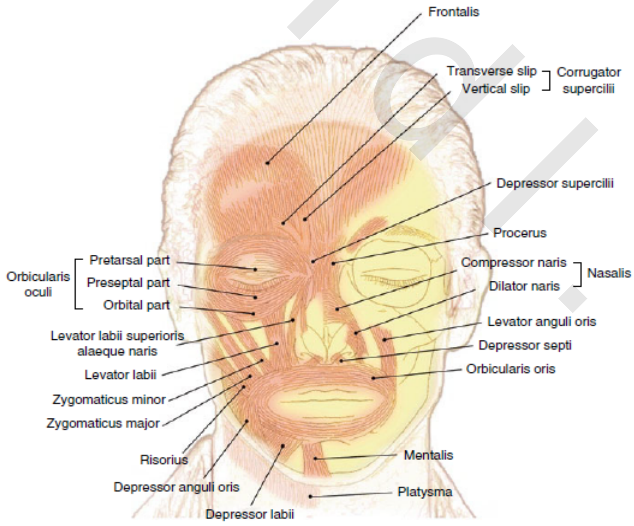

Figure (4): The mimetic facial muscles. [33]

The orbicularis oculi acts as a sphincter around the eye. It consists of three parts: the orbital, preseptal, and pretarsal parts. The orbital part arises from the nasal part of the frontal bone, the frontal process of the maxilla, and the anterior part of the medial canthal tendon. Its fibers pass in concentric loops around the orbit, well beyond the confines of the orbital rim. Contraction causes the eyes to squeeze closed forcefully. Superior fibers also depress the brow. Preseptal orbicularis oculi arises from the medial canthal tendon, passes over the fibrous orbital septum of the orbital rim, and inserts into the lateral palpebral raphe. The pretarsal portion, involved in blinking, overlies the tarsal plate of the eyelid and has similar origins and insertions to its preseptal counterpart. These muscles receive innervations from the temporal and zygomatic branches of the facial nerve.

The corrugator supercilii arises from the superomedial aspect of the orbital rim and passes upward and outward to insert into the dermis of the middle of the brow. From its origin deep to frontalis, two slips of muscle, one vertical and one transverse, pass through fibers of frontalis to reach the dermis. The superficial and deep branches of the supraorbital nerve are intimately related to corrugator supercilii at its origin and are prone to injury during resection of this muscle. Corrugator supercilii depresses the brow and pulls it medially, as in frowning.

The depressor supercilii is a thin slip of muscle that is difficult to distinguish from the superomedial fibers of orbicularis oculi. It inserts into the medial brow and acts as a depressor.

The procerus arises from the nasal bone, passes superiorly, and insert into the dermis of the glabella between the brows. It depresses the lower forehead skin in the midline to create a horizontal crease at the bridge of the nose. Chemodenervation of procerus and corrugator supercilii to alleviate frown lines is one of the most common aesthetic indications for botulinum toxins. Procerus is sometimes debulked during endoscopic brow lift procedures to reduce the horizontal frown crease.

The zygomaticus major and minor are superficial muscles that originate from the body of the zygoma and pass downward to insert into the corner of the mouth and lateral aspect of the upper lip, respectively. They receive their nerve supply on their deep surface from the zygomatic and buccal branches of the facial nerve. Zygomaticus major and minor lift the corners of the mouth.

The levator labii lies deep to orbicularis oculi at its origin from the maxilla just above the infraorbital foramen. It passes downward to insert into the upper lip and orbicularis oris. A smaller slip of muscle medial to this, levator labii superioris alaeque nasi, originates from the frontal process of the maxilla and inserts into the nasal cartilage and upper lip. Both of these muscles are supplied from branches of the zygomatic and buccal branches of the facial nerve and elevate the upper lip.

The levator anguli oris arises deeply from the canine fossa of the maxilla below the infraorbital foramen and inserts into the upper lip. It is innervated on its superficial aspect by the zygomatic and buccal branches of the facial nerve and elevates the corner of the mouth.

The risorius is often underdeveloped and arises from a thickening of the platysma muscle over the lateral cheek, the parotidomasseteric fascia, or both. It inserts into the corner of the mouth and pulls the mouth corners laterally.

The orbicularis oris acts as a sphincter around the mouth and its fibers interlace with all of the other facial muscles that act on the mouth. The buccal and marginal mandibular branches of the facial nerve provide motor supply to orbicularis oris, which has various actions including pursing, dilation, and closure of the lips.

The depressor anguli oris arises from the periosteum of the mandible along the oblique line lateral to depressor labii inferioris. Its fibers converge on the modiolus with fibers of orbicularis oris, risorius, and sometimes levator anguli oris. It is supplied by the marginal mandibular branch of the facial nerve and depresses the mouth corners on contraction.

Depressor labii inferioris arises from the oblique line of the mandible in front of the mental foramen, where fibers of depressor anguli oris cover it. It passes upward and medially to insert into the skin and mucosa of the lower lip and into fibers of orbicularis oris.

The mentalis arises from the incisive fossa of the mandible and descends to insert into the dermis of the chin. Contraction elevates and protrudes the lower lip and creates the characteristic "peach-pit" dimpling of the skin over the chin. Motor supply arises from the marginal mandibular nerve.

The nasalis consists of two parts: the transverse part (compressor naris) and the alar part (dilator naris). The compressor naris arises from the maxilla over the canine tooth and passes over the dorsum of the nose to interlace with fibers from the contralateral side. It compresses the nasal aperture. The dilator naris originates from the maxilla just below and medial to compressor naris and inserts into the alar cartilage of the nose. It dilates the nostrils during respiration.

The depressor septi is a slip of muscle arising from the maxilla above the central incisor, deep to the mucous membrane of the upper lip. It inserts into the cartilaginous nasal septum and pulls the nose tip inferiorly. The nasalis and depressor septi receive innervation from the superior buccal branches of the facial nerve.

The platysma is a broad thin sheet of muscle that arises from the fascia of the muscles of the chest and shoulders and passes upward over the clavicles and neck toward the lower face. Fibers insert into the border of the mandible, perioral muscles, modiolus, and dermis of the cheek. Although variations exist (41), the platysma usually decussates with fibers from the other side 1–2 cm below the mandible. As part of aging, its medial fibers attenuate or thicken to create platysmal bands. Functionally, the platysma depresses the mandible during deep inspiration but is probably more important as a mimetic muscle to express horror or disgust. It is regarded as the inferior most extension of the SMAS and is innervated by the cervical branch of the facial nerve.

Deep Plane Including the Deep Fat Compartments

The superficial fat compartments described above lie above the muscles of facial expression in the subcutaneous plane. In the midface, the suborbicularis oculi fat and deep cheek fat represent deeper fat compartments that provide volume and shape to the face and act as gliding planes within which the muscles of facial expression can move freely.

Suborbicularis oculi fat (SOOF) has two parts, medial and lateral [42]. The medial component extends along the inferior orbital rim from the medial limbus (sclerocorneal junction) to the lateral canthus and the lateral component from the lateral canthus to the temporal fat pad. Between the SOOF and the periosteum of the zygomatic process of maxilla there is a gliding space, the prezygomatic space. This space is bounded superiorly by the orbicularis retaining ligament and inferiorly by the zygomatic retaining ligament (Figure 5) [28].

The sublevator fat pad lies medial to the medial SOOF compartment and represents the most medial of the deep infraorbital fat pads. This fat pad is an extension of the buccal fat pad, behind levator labii superioris alaeque nasi and is continuous below and laterally with the melolabial and buccal extensions of the buccal fat pad [33].

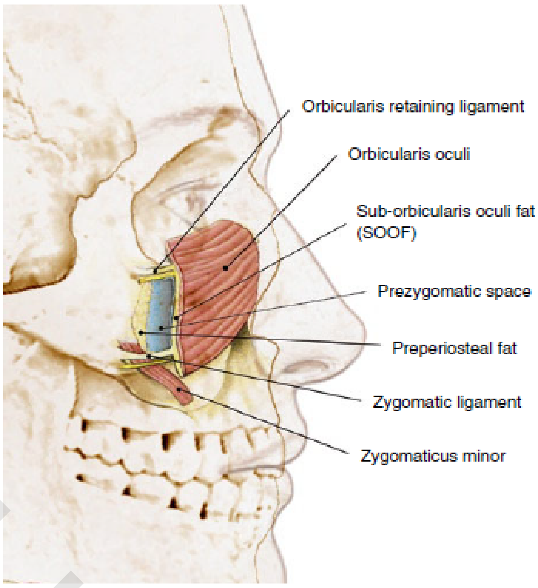

Figure (5): The prezygomatic space [28]

The buccal fat pad is an aesthetically important structure that sits on the posterolateral part of the maxilla superficial to the buccinator muscle and deep to the anterior part of masseter. Functionally, it facilitates a free gliding movement for the surrounding muscles of mastication [43]. As well as the medial extensions described above, it continues laterally as the pterygoid extension (Figure 6). Buccal branches of the facial nerve and the parotid duct travel along its surface within the parotidomasseteric fascia after leaving the parotid gland.

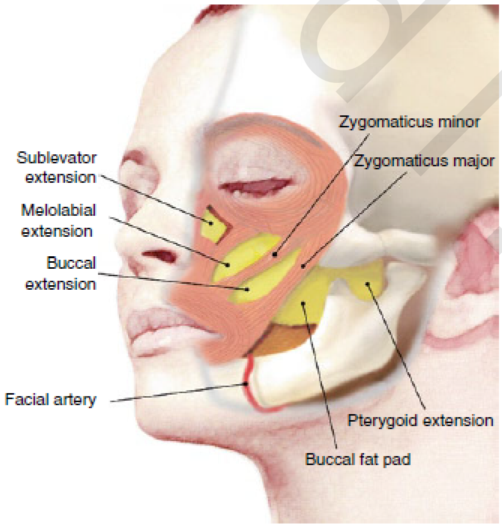

Figure (6): The buccal fat pad and its extensions [28]

The galeal fat pad lies deep to frontalis in the forehead and extends superiorly for about 3 cm [44]. It envelops corrugator and procerus and aids gliding of these muscles during animation. The retroorbicularis oculi fat (ROOF) is part of the galeal fat pad over the superolateral orbital rim from the middle of the rim to beyond the lateral part. It lies deep to the superolateral fibers of preseptal and orbital orbicularis oculi and contributes to the fullness (in youth) and heaviness (in senescence) of the lateral brow and lid. With aging, the retaining ligaments under the eye attenuate. This, together with volume loss in the superficial and deep fat compartments, results in visible folds and grooves in the cheeks and under the eyes (Figure 7).

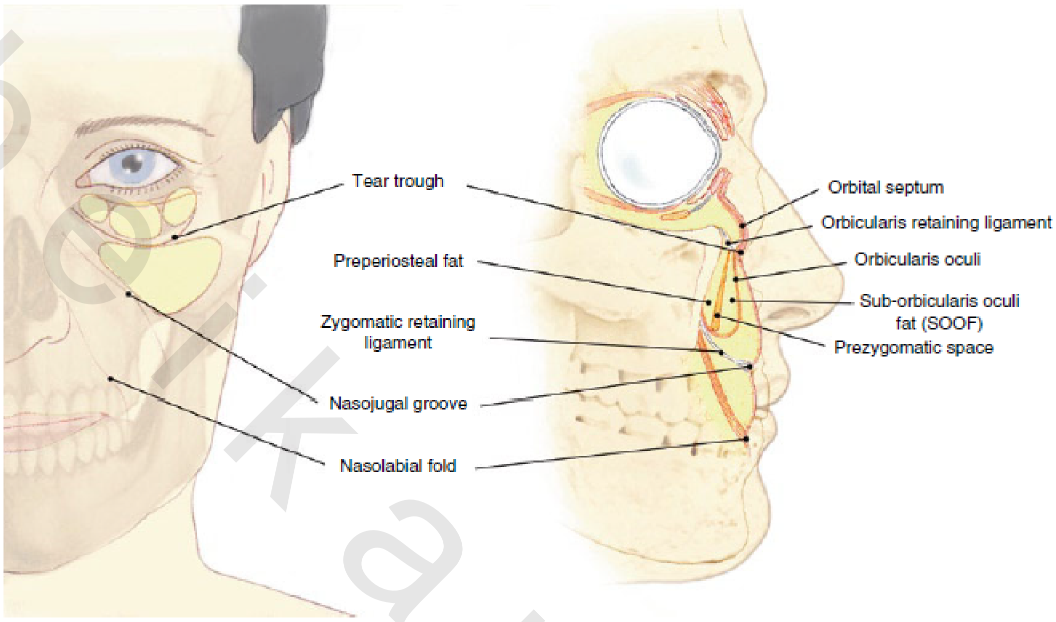

Figure (7): Attenuated ligaments in the midface [43]

The deep cervical fascia covering sternocleidomastoid in the neck continues upward to ensheath the parotid gland between the mandible and mastoid process. The layer of fascia covering the parotid gland and masseter, termed parotidomasseteric fascia, continues superiorly to insert into the inferior border of the zygomatic arch. In the temporal area, the corresponding fascia in the same plane is present as deep temporal fascia, which inserts into the superior border of the zygomatic arch. In the lower face, branches of the facial nerve lie underneath the deep fascia, whereas above the zygomatic arch and in the upper face, facial nerve branches lie superficial to the deep fascia and are susceptible to injury during superficial dissections.

Facial Nerve

The facial nerve (seventh cranial nerve) provides motor innervations to the muscles of facial expression. It begins in the face by emerging from the stylomastoid foramen 6–8 mm medial to the tympanomastoid suture of the skull. Before entering the substance of the parotid gland, the posterior auricular nerve and nerves to the posterior belly of digastric and stylohyoid branch from the main trunk. Within the parotid gland, the facial nerve divides into its main branches: temporal branch, zygomatic branch, buccal branch, marginal mandibular branch, and cervical branch [45] (Figure 8).

The temporal branch of the facial nerve leaves the superior border of the parotid gland as three or four rami. They cross the zygomatic arch between 0.8 and 3.5 cm anterior to the external acoustic meatus, and usually about 2.5 cm anterior to it. At the level of the zygomatic arch, the most anterior branch is always at least 2 cm posterior to the lateral orbital rim. The temporal branches pass in an envelope of superficial temporal fascia with the intermediate fat pad, superficial to the deep temporal fascia. The temporal branch enters frontalis about 2 cm above the brow, just below the anterior branch of the superficial temporal artery.

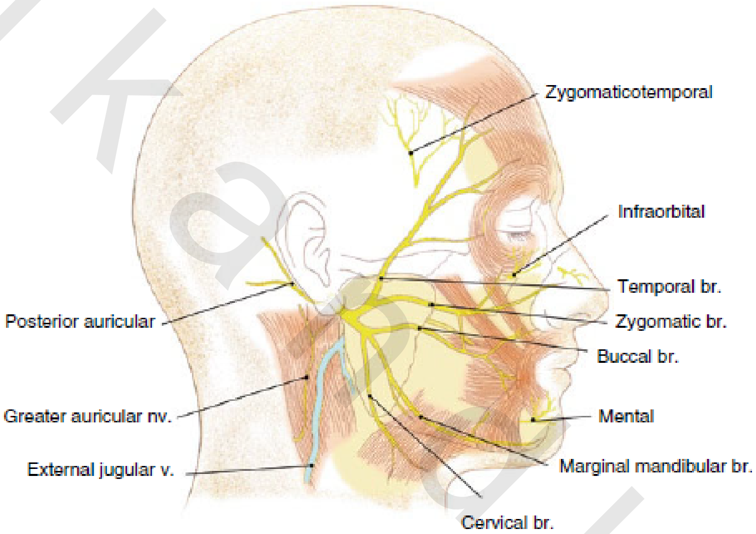

Figure (8): The branches of the facial nerve. Note, the greater auricular, zygomaticotemporal, infraorbital, and mental nerves are sensory nerves. [45]

There are up to three zygomatic branches of the facial nerve. The superior zygomatic branch passes over the orbit to innervate part of orbicularis oculi. The lower branch always passes under the origin of zygomaticus major and supplies this muscle, other lip elevators and the lower orbicularis oculi. Smaller branches continue around the medial aspect of the orbit to supply depressor supercilii and the superomedial orbicularis oculi.

The buccal branch exits the parotid and is tightly bound to the anterior surface of masseter within the parotidomasseteric fascia. It continues anteriorly over the buccal fat pad, below and parallel to the parotid duct, to supply the buccinators and muscles of the upper lip and nose. A second branch is occasionally present, but this travels superior to the parotid duct in its course anteriorly.

The marginal mandibular nerve exits the lower part of the parotid gland as one to three major branches. It usually runs above the inferior border of the mandible, but may drop up to 4 cm below it. About 2 cm posterior to the angle of the mouth, the nerve passes upward and more superficially to innervate the lip depressors. Although it remains deep to the platysma, it is vulnerable to injury during surgical procedures in the lower face at this location.

The cervical branch of the facial nerve passes into the neck at the level of the hyoid bone to innervate the platysma muscle.

Sensory Nerves

The sensory innervation of the face is via the three divisions of the trigeminal nerve (43) (fifth cranial nerve): ophthalmic nerve, maxillary nerve, and mandibular nerve. The ophthalmic nerve supplies the forehead, upper eyelid, and dorsum of the nose via the supraorbital, supratrochlear, infratrochlear, lacrimal, and external nasal nerves. The maxillary nerve supplies the lower eyelid, cheek, upper lip, ala of the nose, and part of the temple, through the infraorbital, zygomaticofacial, and zygomaticotemporal nerves. The maxillary nerve also supplies the maxillary teeth and nasal cavity via the alveolar nerves and pterygopalatine nerves, respectively.

The mandibular nerve has motor and sensory fibers. Its branches include the inferior alveolar nerve, lingual nerve, buccal nerve, and auriculotemporal nerve. These supply the skin over the mandible, lower cheek, part of the temple and ear, the lower teeth, gingival mucosa, and the lower lip. The greater auricular nerve, derived from the anterior primary rami of the second and third cervical nerves, supplies the skin over the angle of the mandible.

The supraorbital nerve emerges from the orbit at the supraorbital notch (or foramen) 2.3–2.7 cm from the midline in men and 2.2–2.5 cm from the midline in women (45). It has superficial and deep branches that straddle the corrugator muscle. Sometimes these branches exit from separate foramina, the deep branch arising lateral to the superficial one. The deep branch usually runs superiorly between the galea and the periosteum of the forehead 0.5–1.5 cm medial to the superior temporal crest line.

The supratrochlear nerve exits the orbit about 1 cm media to the supraorbital nerve and runs close to the periosteum under the corrugators and frontalis. Its several branches supply the skin over the medial eyelid and lower medial forehead.

The infratrochlear nerve is a terminal branch of the nasociliary nerve that supplies a small area on the medial aspect of the upper eyelid and bridge of the nose. The external nasal nerve supplies the skin of the nose below the nasal bone, except for the skin over the external nares. The lacrimal nerve supplies the skin over the lateral part of the upper eyelid. The infratrochlear nerve exits the orbit about 1 cm media to the supraorbital nerve and supplies the skin over the medial eyelid and bridge of the nose.

The infraorbital nerve is the largest cutaneous branch of the maxillary nerve. It enters the face through the infraorbital foramen 2.7–3 cm from the midline in men and 2.4–2.7 cm from the midline in women, about 7 and 6 mm inferior to the inferior orbital rim in men and women, respectively. The nerve appears from the foramen just below the origin of levator labii superioris. It supplies the lower eyelid, ala of the nose, and upper lip. The zygomaticofacial nerve arises from the zygomaticofacial foramen below and lateral to the orbital rim and supplies skin of the malar eminence.

The zygomaticotemporal nerve emerges from its foramen on the deep surface of the zygomatic bone and supplies the anterior temple.

The mental nerve is a branch of the inferior alveolar nerve that exits the mental foramen in line vertically with the infraorbital foramen, between the apices of the premolar teeth. It is often visible and easily palpable through stretched oral mucosa. It supplies the skin over the lower lip and mandible.

The buccal branch of the mandibular nerve supplies the buccal mucosa and skin of the cheek, and the lingual nerve provides sensory innervation to the anterior two-thirds of the tongue and the floor of the mouth. The auriculotemporal nerve emerges from behind the temporomandibular joint to supply the skin of the upper one-third of the ear, the external acoustic meatus, tympanic membrane, as well as the skin over the temporal region. Secretomotor fibers also pass via the auriculotemporal nerve to the parotid gland.

Danger Zones in Surgical Facial Rejuvenation

There are several regions, or danger zones, in the face where branches of the facial nerve lie immediately beneath the SMAS and are prone to injury if sharp dissection is performed in this plane. Nerve injuries can arise as a result of direct transection with sharp instruments, blunt trauma, traction, thermal injury from electrocautery, or inflammation.

Facial nerve injuries can have serious sequelae such as brow ptosis, lid ptosis, lip weakness, and mouth asymmetries. Although most iatrogenic facial nerve palsies following aesthetic surgery are temporary, they can be distressing and may take months to fully recover [47]. As such, preventing nerve injuries by careful planning, meticulous technique, and a sound knowledge of the precise location of important motor and sensory nerves in relation to the path of dissection is crucial.

Zone 1

At the level of the zygomatic arch, the temporal branch of the facial nerve emerges from the substance of the parotid and passes over the bony arch toward the frontalis muscle between two slips of superficial temporal fascia. The nerve is prone to injury during its course superficially in this zone.

Although variations exist, the nerve always crosses the zygomatic arch between 0.8 and 3.5 cm anterior to the external auditory meatus (EAM), and not less than 2 cm posterior to the lateral orbital rim [45]. The temporal branch of facial nerve is usually described as having a consistent course from 0.5 cm below the tragus to 1.5 cm above the lateral brow [48].

However, soft tissue landmarks are not always reliable and should not be used as definite guides to the position of the nerve. More accurately, the nerve can be found 2.1–4 cm above the bony lateral canthus [45]. Therefore, this zone can be considered a triangle, with its base along the zygomatic arch from 0.8 to 3.5 cm anterior to the anterior border of EAM. A vertical line dropped from the superior part of the tragus represents the anterior border of EAM. A line is drawn from the anterior limit of the first line, superiorly to a point 4 cm above the bony lateral canthus, representing the anterior border of this danger zone. A straight line connecting the first two lines completes the triangular danger zone (Figure 9).

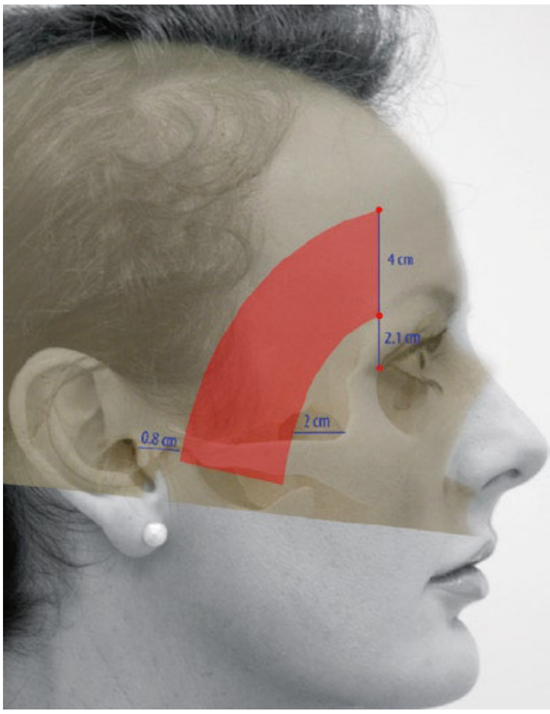

Figure (9): Dangerous zone 1 [47] This danger zone (*red*) extends from the inferior border of the zygomatic arch to a line above the bony lateral canthus. The zone curves anteriorly as shown from the lower line to the upper one. Within this zone, the temporal branch of the facial nerve is vulnerable to injury where it passes superficially in the superficial temporal fascia

Dissecting immediately deep to the superficial temporal fascia above the zygomatic arch should be avoided. It is safe to dissect immediately below the dermis in the subcutaneous plane above the superficial temporal fascia [49], deep to the superficial temporal fascia along the deep temporal fascia [50], or under the deep temporal fascia. Injury to the temporal branch of the facial nerve results in weakness or paralysis of the ipsilateral frontalis muscle, leading to brow ptosis and smoothing of the forehead above the brow. Orbicularis oculi is usually spared since it also receives motor innervation from superior branches of the zygomatic branch of the facial nerve.

Zone 2

The zygomatic and buccal branches of the facial nerve emerge from the anterior border of the parotid invested in the parotidomasseteric fascia. There are up to three zygomatic branches and one or two buccal branches. The superior zygomatic branch passes over the orbit to innervate part of orbicularis oculi. Lower branches supply the lip elevators; one of the lower zygomatic branches always passes posterior to the origin of zygomaticus major on the body of the zygoma. The buccal nerve passes on the surface of the buccal fat pad below and parallel to the parotid duct and supplies the lip elevators, orbicularis oris, and nasalis. When a second buccal nerve is present, it passes above the parotid duct.

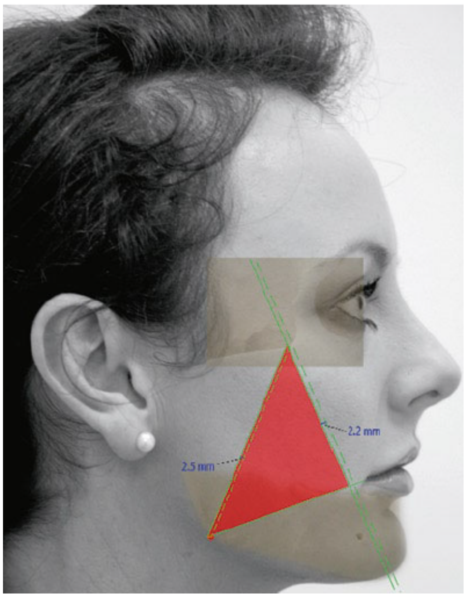

Figure (10): Danger zone 2 (47). The anterior continuous green line represents the most anterior position of the lateral border of zygomaticus major. The posterior continuous green line marks the most posterior part of the anterior border of the parotid gland. The borders of this triangular danger zone are formed in relation to these lines, with the base of the triangle running from the masseteric tuberosity at the angle of the mandible toward the oral commissure. The zygomatic and buccal branches of the facial nerve occupy this zone as they run on the buccal fat just underneath platysm.

The danger zone for these nerves lies anterior to the parotid and posterior to zygomaticus major and minor, where only the SMAS protects them (Figure 10). The anterior border of parotid can be found by drawing a line from the most anterior inferior aspect of the temporal fossa to the masseteric tuberosity. Wilhelmi found that the most posterior part of the anterior border lies up to 2.5 mm posterior to this vector [51]. The upper lateral border of zygomaticus major is intimately related to the zygomatic branch of the facial nerve. The lateral border of zygomaticus major can be estimated to be 2.2–6.6 mm lateral and parallel to a line drawn from the mental protuberance to the most anterior inferior aspect of the temporal fossa [52].

The nerves, as well as parotid duct and facial vessels, are susceptible to injury during extended sub-SMAS dissections or composite rhytidectomy. Dissection should be performed only under direct vision in this zone. Signs of injury to the zygomatic and buccal branches of the facial nerve include weakness in forcefully closing the eyes, drooping of the ipsilateral upper lip and oral commissure, and significant asymmetry at rest and during animation [53, 54]. Since orbicularis oculi receives dual innervation from the temporal and zygomatic branches, complete iatrogenic paralysis of this muscle is rare following aesthetic surgery.

Zone 3

The marginal mandibular branch of the facial nerve emerges from the anterior aspect of the parotid as one to three main branches and runs along the mandible deep to the cervical fascia toward the lip depressors. The nerve usually runs along the inferior border of the mandible, but may drop up to 4 cm below it [55]. It starts its course deep to the cervical fascia, but pierces the fascia approximately halfway along the body of the mandible to lie just deep to the SMAS. Anteriorly, the nerve is prone to injury where the overlying SMAS becomes very thin and the nerve courses more superficially toward depressor anguli oris and depressor labii. About 2–3 cm posterior to the oral commissure, the nerve is most vulnerable where it crosses superficial to the anterior facial artery and vein. These vessels are also prone to injury during sub-SMAS dissections in this area. As such, this danger zone is defined by a circle with a radius of 2 cm with its center located 2 cm posterior to the oral commissure at the inferior border of the mandible (Figure 11).

Figure (11): Dangerous zone 3 (47). The marginal mandibular nerve occupies this danger zone, represented by a circle centered on the inferior border of the mandible, 2 cm posterior to the oral commissure. The nerve courses superficially in this zone

In this danger zone, the nerve can be injured during overzealous subcutaneous dissections from above or below when redraping the soft tissues over the mandible. Care should be taken to stay in the superficial subcutaneous plane in the jowl to avoid breaching the platysma where it exists only as a thin layer. Similarly, aggressive liposuction of the jowl should be avoided.

The smile is asymmetric with an inability to show the lower teeth on the affected side. Abnormal lower lip elevation is also a sign of cervical branch injury due to weakness of platysma. However, since the mentalis receives innervation from the marginal mandibular nerve, the patient can still evert the lower lip if the marginal mandibular nerve has been spared (56).

Zone 4

This danger zone includes the supraorbital and supratrochlear nerves, branches of the ophthalmic division of the trigeminal nerve, and sensory nerves to the upper eyelid and forehead. The supraorbital nerve emerges from the supraorbital foramen or notch 2.3–2.7 cm from the midline in men and 2.2–2.5 cm from the midline in women (46).

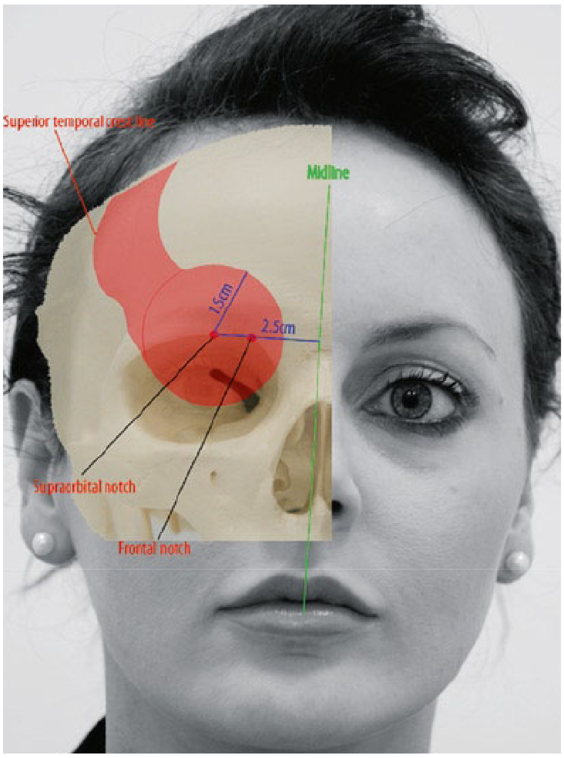

Figure (12): Dangerous zone 4 [47]. A circle of 1.5 cm diameter is centered on a point 2.5 cm from the midline along the supraorbital ridge, or on the supraorbital foramen or notch if palpable. The danger zone extends from the superolateral part of the circle along the superior temporal crest lines and for 1.5 cm medial to it, where the deep branch of supraorbital nerve passes on the periosteum.

The supratrochlear nerve appears from its foramen or notch about 1 cm medial to the supraorbital nerve. Then supraorbital nerve has superficial and deep branches that straddle the corrugators muscle. Sometimes, the deep branch arises from its own foramen lateral to the superficial branch. These nerves are most commonly injured during coronal or endoscopic brow lift procedures where direct trauma or traction on the nerves leads to numbness or dysesthesias over the upper eyelid, dorsum of the nose, medial forehead, and scalp [57].

Zone 5

This danger zone lies over the maxilla under the eye to include the infraorbital nerve. The nerve enters the face through the infraorbital foramen 2.5–3 cm from the midline, about 7 mm below the inferior orbital rim. The nerve appears from the foramen just below the origin of levator labii superioris. The infraorbital nerve is a branch of the maxillary division of the facial nerve and provides sensory innervation to the lower eyelid, cheek, side of the nose, and upper lip. The danger zone is a circular area centered on the foramen, with a diameter of 3 cm (Figure 13).

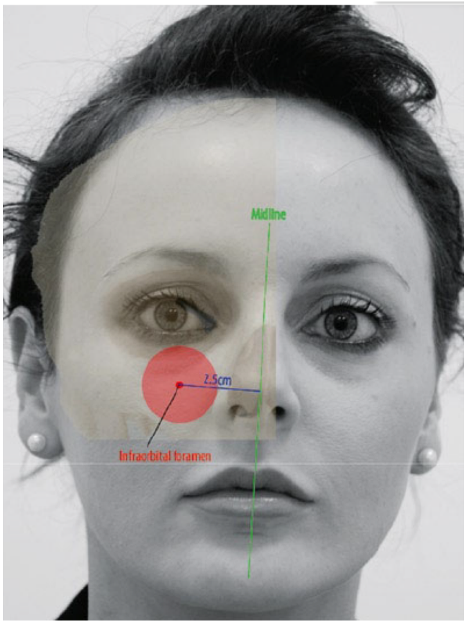

Figure (13): Dangerous zone 5 (47). This danger zone is circular, centered on the infraorbital foramen. The foramen is usually 2.5 cm from the midline, close to the midpupillary line.

Deep dissection in this area, such as during an extended subperiosteal facelift, can place the nerve at risk of injury. Subperiosteal dissections on the anterior maxilla can also injure the infraorbital vessels and the zygomatic branches of the facial nerve. Direct visualization of these nerves and vessels using endoscopy may help prevent such injuries (58). Trauma to the infraorbital nerve presents as numbness, dysesthesia, or hypesthesia of the skin it innervates.

Zone 6

The mental nerve is susceptible to injury during genioplasty either through a buccal or submental incision when the dissection is performed on the periosteum. The nerve arises roughly in line with the infraorbital and supraorbital nerves, emerging from the mental foramen below the lower second premolar tooth. A circle of 3 cm diameter centered on the mental foramen defines this danger zone (Figure 14). Injury to the mental nerve can result in numbness of the lower lip, chin, and mucous membrane on the same side. Drooling can also occur due to sensory loss in this area.

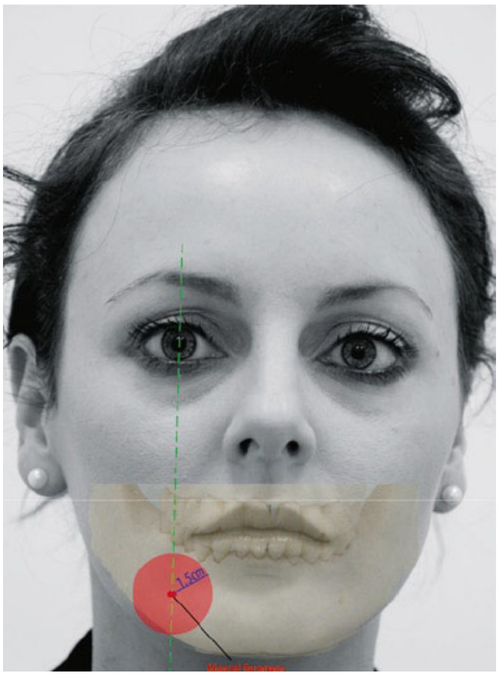

Figure (14): Dangerous zone 6 [47]. A circular area of 3 cm diameter centered on the mental foramen defines this danger zone. Note that the foramen is approximately in the midpupillary line.

Zone 7

The greater auricular nerve arises from the anterior primary rami of the second and third cervical nerves. It provides sensory innervation to the lower two-thirds of the auricle, the skin underneath the ear, and the posterior two-thirds of the jawline. The nerve pierces the deep cervical fascia at the posterior border of sternocleidomastoid and runs on the muscle, superficial and posterior to platysma toward the angle of the jaw. At a point 6.5 cm inferior to the external auditory canal, the nerve can be found halfway between the posterior and anterior borders of the sternocleidomastoid [59]. Below the ear it divides into anterior and posterior branches.

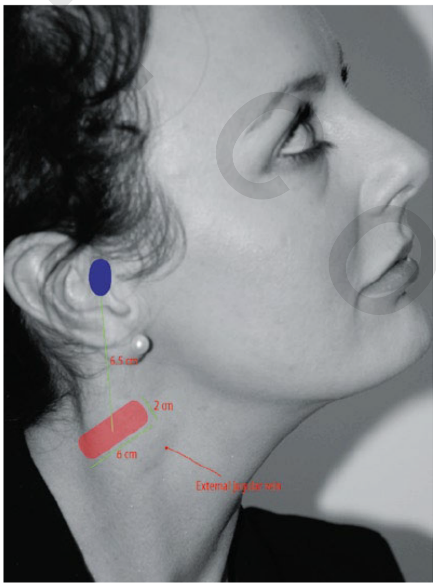

Figure (15): Dangerous zone 7 [47]. This lies 6.5 cm below the external auditory meatus, in the middle of sternocleidomastoid, parallel to the external jugular vein. The greater auricular nerve is prone to injury as it passes through this danger zone behind the border of platysma.

This danger zone can be considered as an oblong, 2 cm wide and 6 cm long, with its center on a point 6.5 cm below the external auditory meatus oriented parallel to the external jugular vein (Figure 15). The greater auricular nerve is prone to injury during neck dissections and suture plication of platysma to the mastoid fascia.

Arteries of the Face

The skin and soft tissue of the face receive their arterial supply from branches of the facial, maxillary, and superficial temporal arteries – all branches of the external carotid artery. The exception is a masklike area including the central forehead, eyelids, and upper part of the nose, which are supplied through the internal carotid system by the ophthalmic arteries (43) (Figure 16).

The facial artery arises from the external carotid and loops around the inferior and anterior borders of the mandible, just anterior to masseter. It pierces the masseteric fascia and ascends upward and medially toward the eye. It lies deep to the zygomaticus and risorius muscles but superficial to buccinator and levator anguli oris (60). At the level of the mouth, the facial artery sends two labial arteries, inferior and superior, into the lips where they pass below orbicularis oris. The continuation of the facial artery near the medial canthus beside the nose is the angular artery.

The maxillary artery is a terminal branch of the external carotid with three main branches, mental, buccal, and infraorbital arteries. The mental artery is the terminal branch of the inferior alveolar artery that passes through the mental foramen to supply the chin and lower lip. The buccal artery crosses the buccinators to supply the cheek tissue. The infraorbital artery reaches the face through the infraorbital foramen and supplies the lower eyelid, cheek, and lateral nose. It anastomoses with branches of the transverse facial, ophthalmic, buccal, and facial arteries.

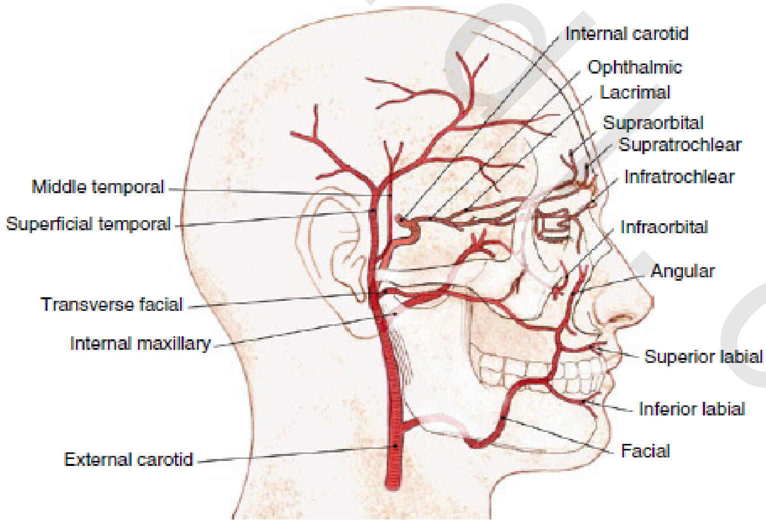

Figure (16): Arterial supply to the face (28)

The superficial temporal artery is the terminal branch of the external carotid artery. In the substance of the parotid, just before reaching the zygomatic arch, it gives off the transverse facial artery which runs inferior and parallel to the arch and supplies the parotid, parotid duct, masseter, and skin of the lateral canthus. The superficial temporal artery crosses the zygomatic arch superficially within the superficial temporal fascia. Above the arch, it gives off a middle temporal artery that pierces the deep temporal fascia and supplies the temporalis muscle. Thereafter, about 2 cm above the zygomatic arch, the superficial temporal artery divides into anterior and posterior branches. The anterior branch supplies the forehead and forms anastomosis with the supraorbital and supratrochlear vessels. The posterior part supplies the parietal scalp and periosteum.

The ophthalmic artery is a branch of the internal carotid system (Figure 9). Its branches include the lacrimal, supraorbital, supratrochlear, infratrochlear, and external nasal arteries. There is significant communication between the external and internal carotid artery systems around the eye through several anastomoses.

Changes in the Aging Face

The anatomic changes in the aging face should be understood profoundly to manage them effectively (61). Flat muscle activation on the face causes wrinkling of the overlying skin. In young individuals, who have elastic skin, this wrinkling is temporary, whereas in older individuals, who have lost the elasticity of the skin, the wrinkles (or the folds) become permanent (62). Other factors that contribute to the development of the wrinkles are solar damage, dry weather, progressive loss of some facial fat, and degeneration of the connective tissue (61).

Yousif (61) found that midfacial soft tissue descends inferiorly, laterally, and anteriorly. He pointed out that since the most anterior part of the malar fat is the most distant part of the face away from the constant skeleton, it descends the greatest distance. The other reason is that in contrast to the other parts of the face that are supported by the activity of the mimic muscles, the cheek area is supported by the retaining ligaments that attenuate with time, as stated already. Stuzin et al. (29) also stated that the aging face develops as a result of attenuated facial retaining ligaments and dermal elastosis.

Attenuation of the malar ligaments results in malar descent, causing the nasolabial fold to become more accentuated (29). Attenuation of the masseteric cutaneous ligament leads to descent of the medial cheek, causing the jowls (29). They advocated that management of the aging face should be directed to these changes.

Hamra (63) described three main ptotic deep anatomic elements that are seen in addition to the skin changes with aging. First are the jowls or the broken mandibular line that develops with ptosis of the platysma muscle. Second is the enhanced distance between the ciliary margin and the malar crescent, which he defined as the inferior border of the orbicularis oculi muscle. The malar crescent descends as a result of attenuated orbicularis oculi muscle. And third are the deepened nasolabial fold and the depressed cheek that develop as a result of ptosis of the cheek fat. He addressed all these three changes in his method “the composite rhytidectomy”

Yousif (61) stated that the nasolabial fold does not change nor deepen, and it is the descending of the cheek that makes the difference between the nasolabial fold of youth and age. There are important changes on the lower lid and the infraorbital area. Goldberg et al. (64) found that there are various causes responsible for the eyelid bags. The most common factors are orbital fat prolapse, lower-lid elasticity, and tear-trough deformity. They stated that these factors become more prominent with age.

Aiache and Ramirez [65] stated the causes of the malar bags as the inferior palpebral edema, subcutaneous fat excess, skin relaxation, and the herniation of the SOOF at the malar level. Furnas [66, 67] defined the festoons as the overlapping folds of the orbicularis oculi muscle that are suspended from canthus to canthus as a result of attenuation of the muscle and laxity of the attachments between the muscle and the deep fascia with aging. They contributed to the baggy eyelids. Furnas [66, 67] classified the festoons with respect to their locations and contents. They may appear on the upper or lower lid. The lower-lid festoons are classified as pretarsal, preseptal, orbital, and malar. They may contain only muscle (pure skin–muscle festoons) or muscle with fat tissue that originated from the bulging preaponeurotic orbital fat or the SOOF. In some cases a cutaneous dewlap develops as a result of attenuation of the muscle– skin connection. The folds make the borders of the malar mound become more prominent as a result of lax skin with aging as mentioned above [67].

The changes around the perioral area include elongation of the upper lip resulting in loss of symmetry and convexity, thinning of vermilion with loss of shape, commissural drooping and sad pleats, and formation of radial lines from the vermilion extending onto the upper and lower lips. The changes on the nose include involution of the sebaceous glands and thinning of the skin and drooping of the tip. These changes should be addressed by means of adjuvant procedures to improve the overall result [68].

Different facelift methods

I. Skin Excision without Undermining and Classic Subcutaneous Face Lifting

Early attempts at face-lifting procedures consisted of skin excision and primary repair without skin undermining (Figure17). These have been called minilifting procedures. Hollander, Lexer, and Joseph stated in the 1920s and 1930s that they performed their first operations at the beginning of the twentieth century [5-7]. However, Miller and Kolle were the first to have their methods published, in 1906 and 1911, respectively [8-10].

Passot, Bourget, and Noel [11-13] were the other pioneers of midface lifting in the first half of the twentieth century. They carried out different shapes of excisions (ellipsoid, S-shape, ovoid, crescent, etc.) and concealed them at the frontal hairline, inside the temporal hair, and behind and in front of the ear. Hollander used a longer incision that included the preauricular, infralobular, and lateral neck skin areas to obtain more effective results [5]. Passot limited his incisions to the sideburns for men and to the long hair fall in the women. Bettman was probably the first to employ an incision similar to the one that is used today [14]. His incision started from the temporal area and included the preauricular, infralobular, and postlobular areas. Bourget concealed the preauricular incision on the tragus [13]. His incision continued around the earlobe in a V-fashion, ascended on the retroauricular furrow, then angled onto the mastoid, and finally extended through the hairline.

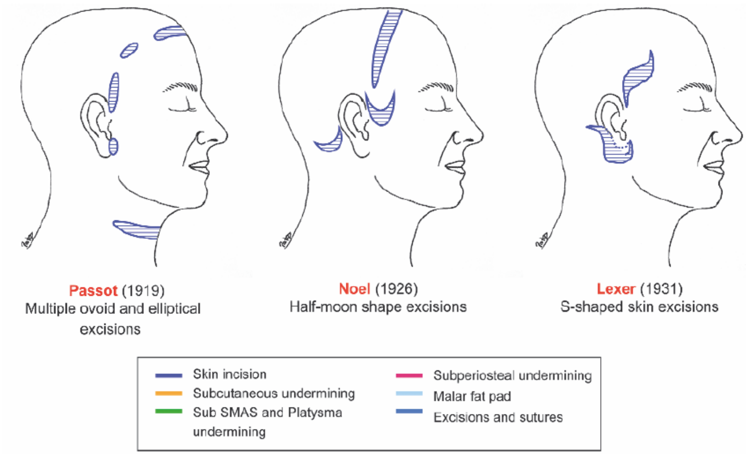

Figure (17): Skin excision only without undermining (69)

In the 1920s and 1930s, some surgeons extended their incisions and began to perform subcutaneous undermining to obtain long-lasting results leading to the classic subcutaneous face-lifting period (Figure 18). Bames, Stein, Joseph, and Bourget were some of the pioneers in this period. Bames performed limited subcutaneous dissection in the 1920s, whereas Claoue and Burian used extended undermining [14]. Bourget extended the dissection as near as possible to the nasolabial fold and the neck [2].

Gonzales-Ulloa [70] performed dissection at the frontal, midfacial, and cervical areas after a long incision that started behind the frontal hairline and extended to the temporal area, preauricular furrow, retroauricular sulcus (that united with the temporal incision completing a circle around the pinna), and the occipital scalp. After wide dissection he pulled out the tissues in different vectors with respect to the effects of the gravitational force on each region, and then excised the excess tissue.

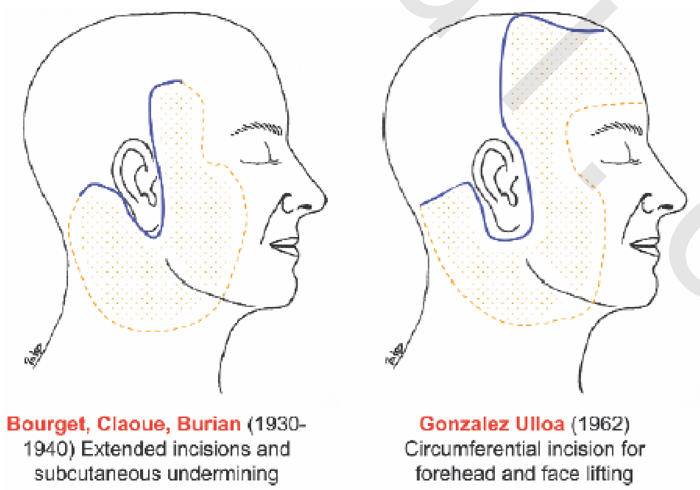

Figure (18): Classic methods: extended incisions plus skin undermining (69)

II. Sub-SMAS-Plane Face Lifting

Classic subcutaneous face lifting was the main method until the 1970s. One of the disadvantages of the minilifts and the subcutaneous face-lifting methods is that they address only the skin laxity, neglecting the ptosis of the deeper layers [61]. The subcutaneous face lifting does not offer an effective improvement, and carries high risk of tight or drawn-out appearance because of lateral traction (71).

Skoog's (19) introduction of his method "two layer shift" in his book in 1974 heralded a new period (Figure 19). He briefly carried out limited subcutaneous dissection after temporal and preauricular incisions and then entered deeper to the superficial fascia of the face at the level of the anterior border of the masseter and continued his dissection through the nasolabial fold. After postauricular incision he carried out subcutaneous incision to the sternocleidomastoid and submandibular level (avoiding the facial nerve), after which he entered the subplatysmal level. He applied traction to the subcutaneous facial fascia and to the platysma in a posterior and superior direction and fixed these tissues to the masseteric and mastoid fascias, respectively. By doing this, he tried to correct the jowls and the nasolabial folds, provide fullness for the cheeks, and advance the skin and subcutaneous tissue further without tension.

He stated the advantages of his operation as more even distribution of the tissues when compared with previously performed plication of the deeper tissues, and less hematoma and scarring, and more permanent results when compared with subcutaneous face lifting.

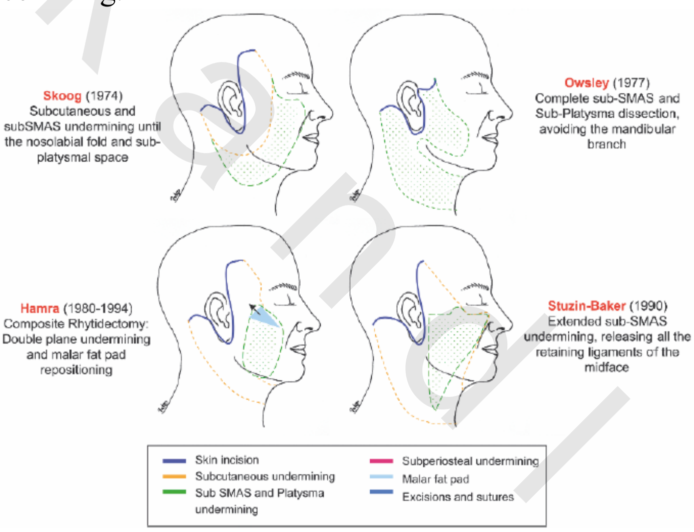

Figure (19): The subcutaneous musculoaponeurotic system rhytidectomy (69)

Skoog's method in addition to the anatomic studies of Mitz and Peyronie led Owsley (72) to employ sub-SMAS–platysma dissection (Figure 19). He elevated the SMAS from the zygomatic arch down to the neck at the subplatysmal level, avoiding the marginal mandibular nerve at the mandibular level. The SMAS was then fixed to the pretragal area.

Lemmon and Hamra (24) modified Skoog's technique by adding cervical subcutaneous dissection, submental lipectomy, and submandibular lipectomy in selected cases. Additionally, they did not extend the dissection to the level of nasolabial fold because it did not produce further improvement.

Hamra (63, 72-76) later modified this sub-SMAS face-lifting method with more effective methods and developed the triplane dissection, the deep-plane dissection, and the composite rhytidectomy methods (Figure 19). He limited sub-SMAS dissection below the malar eminence, and performed subcutaneous dissection in a great part of the midface and the neck to obtain longer-lasting results and to avoid the operated-on appearance of the neck often seen after subplatysmal dissection (the triplane dissection). In order to improve the nasolabial fold, for which he stated that Skoog's method was not very effective, he developed the deep-plane dissection. He created a musculocutaneous flap after limited skin dissection and sub-SMAS dissection at the level of malar eminence, the jawline and beyond the nasolabial fold, and suspended the flap to the superficial temporal fascia. He later added suborbicularis oculi dissection via subciliary incision to suspend it in a medial and superior direction and named this technique "the composite rhytidectomy." As a result he was able to manage the jowls, nasolabial fold, and the malar crescent. He also added repositioning of the inferior-lid fat pad and canthopexy operations, when needed.

Connell and Semlacher [77] introduced Connell's method of "contemporary deep-layer facial rejuvenation" in 1997 after using it on more than 1,500 patients with satisfactory results. He limited the subcutaneous dissection to preserve the anterior SMAS and dermis connection lateral to the nasolabial fold to obtain the desired effect on the nasolabial fold, upper lip, and corner of the mouth with later traction of the SMAS.

He created a SMAS flap with a horizontal incision at the level of (or just above or beyond it) the zygomatic arch that extended from the malar eminence to the pretragal area, and a vertical incision that extended from the posterior end of the horizontal incision to the level of the anterior sternocleidomastoid muscle. He then pulled the flap superiorly and posteriorly around the malar pivot point and fixed it. He further divided a horizontal segment from the superior part of the SMAS flap and suspended it to the lateral temporal and periorbital tissues when more improvement was needed for the midface; or he divided a vertical segment from the posterior part of the flap and suspended it to the mastoid fascia when more improvement was needed on the neck.

Stuzin et al. [29, 78, 79] performed extended SMAS dissection far enough to release the parotid gland and the zygomatic and superior masseteric ligaments and to elevate and suspend the malar fat pad especially in patients with prominent nasolabial folds (Figure 19). Stuzin carried out more limited skin dissection to preserve the attachments between the skin and the SMAS that would allow the surgeon to re-elevate the facial skin through SMAS rotation. He named his method "the extended SMAS dissection technique" He stressed the importance of leaving a thick enough layer on the SMAS to obtain an adequately strong tissue for suspension, to give more fullness to the malar area. In case of a thin SMAS, he rolled the excess tissue onto itself to provide a thickened layer for fixation as suggested by Lambros [79]. He later began to put a Vicryl mesh graft inside the roll to obtain extra strength. He pointed out that aging changes occur in the face in different vectors and added that the extended SMAS dissection technique enables one to lift these tissues separately in different directions.

The main advantages of this were suspension of the skin a bit more lateral than the SMAS so as not to cause misdirected facial rhytids and to allow the surgeon to redrape the individual layers with respect to the specific needs of the patient, since every patient ages differently in terms of both the degree of skin aging and the direction of the facial fat descent. He stated that the disadvantage of subcutaneous face lifting is that it results in an unnatural, tight, mask appearance and it distorted temporal hairlines after over-rotation of the skin flap, and that it is not an anatomic approach to correct descended facial fat by traction of the skin flap.

Although he stated that there was little morbidity with his method, Stuzin pointed out the transition of the cheek and malar SMAS as the most difficult portion of the dissection because the fascia is too thin at this location and the atypically superficial course of the zygomatic motor branches in some patients (approximately 5%) makes these structures susceptible to injury during the dissection. Jost and Levet [80] criticized the dissection below the superficial fascia (sub-SMAS), because it provides a thin fatty flap. Alternatively, they advocated dissection below the parotid fascia (primitive platysma) to obtain a stronger, thicker flap with protection of the facial motor branches. Their recommendations were based on their cadaver and histology studies.

Baker [81] also criticized extensive SMAS dissection plication methods; the first method in terms of possible injury to the facial nerve branches and thinning out of the SMAS anteriorly that makes it fragile and a poor substrate for holding the tension, and the second method in terms of application of tension on the more stable posterior part of the fascia. He proposed excising a portion of the SMAS on the lateral aspect of the parotid to avoid the motor branches and then advancement and fixation of the more mobile anterior SMAS to the more stable posterior part without undermining. He introduced his method as “the lateral SMASectomy” (Figure 20).

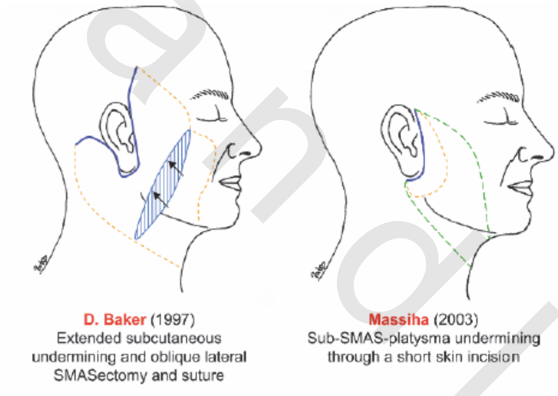

Figure (20): Rhytidectomy techniques by Baker and Massiha [69]

The short scar face lift and extended SMAS dissection technique that was described by Massiha [30] relies on a short skin incision with limited subcutaneous dissection to avoid dog-ears to be removed and to protect the dermal–SMAS connections, and on the extensive sub-SMAS and platysma dissection for correction of the aging deformities (Figure 20). The skin incision was started at the sideburn and extended more or less with respect to the needs of the patient to the postlobule area.

III. Subperiosteal Face Lifting, Mask Lift:

The subperiosteal face-lifting period started at the end of the 1970s and in the 1980s, pioneered by Tessier [82], Hinderer et al. [83], Psillakis et al. [84], and Ortiz Monasterio et al. [85, 86] and contributed to the craniofacial methods (Figure 21). Tessier [82] and Psillakis et al. [84] first dissected the frontal, periorbital, and zygomatic areas subperiosteally after coronal incision. Psillakis et al. extended the subperiosteal dissection to the midface.

Studying cadavers, they proposed the term "the anterior face SMAS fixation" in referring to fixation of the SMAS and the muscles to the underlying bone. They advocated release of this fixation for effective lifting. After coronal incision, they performed subgaleal dissection through the supraorbital area, from which they carried on with subperiosteal dissection. They extended the subperiosteal dissection to the infraorital foramen, the medial third of the zygomatic arches, and the level of the nasolabial fold, and then fixed the dissected tissues to the deep temporal fascia. Ortiz-Monasterio et al. (85, 86) solved the problem of the horizontal or anti-Mongoloid eye slant problem with repositioning of the lateral canthus.

Some authors used lower-lid incisions to reach the midface subperiosteally (87-90). Hester et al. (88, 89) in their centrofacial approach method created a subperiosteal cheek flap that included the SMAS, the SOOF, the malar fat pad, and the orbicularis oculi via a subciliary approach and after the subperiosteal dissection. They pulled this flap vertically and fixed it to the deep temporal fascia. Gunter and Hackney (90) in contrast excised the periosteum at the borders of the dissection, creating a composite flap, and fixed it to the lateral orbital rim in order to avoid canthopexy or canthoplasty operations.

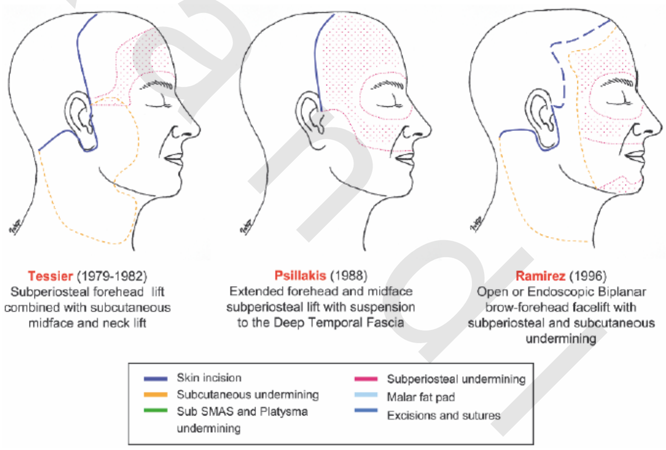

Figure (21): The subperiosteal facelift (69)

Hobar and Flood (76) used temporal and intraoralincisions to elevate the midfacial tissues subperiosteally. They suspended the SOOF and fixed it to the deep temporal fascia. By doing this, they avoided lower-lid incisions, and consequently the accompanying potential lower-lid problems.

Ramirez et al. (25) described their open method, "the extended subperiosteal face lift" in 1991. They stressed the high probability of facial branch injury with the subperiosteal face-lifting methods of Tessier (82) and Psillakis et al. (84) They criticized the method of Psillakis et al. for limited dissection on the zygomatic arch that resulted in limited lifting and for using the periorbital fibrofatty tissues that would risk the zygomatic branches of the facial nerve.

After coronal or modified hairline incision, Ramirez et al. (25) dissected subperiosteally in the frontal area. In the temporal region, they dissected superficial to the deep temporal fascia. They first entered into the fat pad between the layers of the temporalis fascia proprium, and then behind the deep layer of this fascia above the zygomatic arch. Arriving at the arch with further dissection, they again incised the fascia proprium and the periosteum of the arch. With addition of the intraoral incision, they dissected a wide area of the midface, including a part of the masseter fascia. Then they advanced the coronal flap, lifting the midfacial structures, and anchored the temporalis muscle fascia on the flap to the temporal fascia behind the fascial incision (rather than suspending the periorbital soft tissue). They also added limited subcutaneous dissection on the parotid area and the neck, when needed.

Ortiz-Monasterio (92), discussing the presentation of Ramirez et al. concerning their extended subperiosteal face lift method, recommended this procedure for younger patients who have sagging around the orbitozygomatic area. He advocated the necessity of the addition of the preauricular and neck incisions for older patients.

Heinrichs and Kaidi (93) criticized the dissection of Ramirez et al. (25) on the temporal region for being too bloody and for possible temporal fat atrophy. After temporal scalp incision they completed subtemporoparietal fascia dissection to the level of the V1 vein level above the zygomatic arch, after which they exposed the posterior arch through a back-cut in the SMAS and subcutaneous tissue immediately anterior to the tragus.

Further subperiosteal dissection of the arch provided connection to the midfacial subperiosteal dissection that was previously carried out via an intraoral or subciliary incision. The second difference in their method was that they created a temporal SMAS–galea flap at thetemporal incision. Then they suspended and fixed the SOOF and the SMAS–galea flap to the deep temporal fascia.

IV. The Suspension Methods and MACS-Lift:

Some authors performed suspension and fixation of the malar fat pad to improve the nasolabial fat. Owsley (23) extended his sub-SMAS dissection underneath the malar fat pad to the level of the nasolabial fold. He then suspended and fixed this structure to the fascia over the malar eminence.

Robbins et al. (94) used subcutaneous dissection through the line drawn from the lateral canthus to 1–2 cm lateral to the corner of the mouth to expose the malar fat pad and suspended this structure laterally. Collawn et al (95) and de la Torre et al. (96) combined these two methods to eliminate their disadvantages (lateral traction of both the skin and the fat pad in the method of Robbins et al. (94) and vertical suspension of the fat pad in spite of lateral traction of the skin in the method of Owsley (23), exposing the malar fat pad through a subcutaneous dissection and lifting the skin and the malar fat vertically.

Byrd and Andochick (97), in their "the deep temporal lift" method, performed a subgaleal approach to the forehead, a subfascial approach to the temporal region, a subperiosteal approach to the zygomatic arch, and a suborbicularis approach to the orbital rim. Then they suspended the midfacial periosteum and the superficial temporal fascia to the deep temporal fascia.

Finger (98) in contrast to the previous methods that enter the subperiosteal plane through the intraoral or temporal incisions, used the transmalar approach and presented his method as "transmalar subperiosteal midface lift with minimal skin and SMAS dissection" After the subcutaneous dissection, he entered the subperiosteal plane at the level of the zygoma just cephalad to the origins of the zygomaticus muscles by using a periosteal elevator. After subperiosteal undermining of the midface lateral to the infraorbital rim, he suspended and fixed the periosteum to the deep temporal fascia.

Sasaki and Cohen (99) used their specially designed percutaneous suspension sutures and fixed the malar fat to the deep temporal fascia. Sulamanidze et al. (100, 101) used a subcutaneous thread system for the same purpose. The authors, aiming at obtaining a long lasting improvement, have begun to dissect deeper to the superficial temporal fascia and the malar fat pad via a short temporal incision and to fix the malar fat pad to the deep temporal fascia by using the threads.

Noone (102) combined the SMAS plication, modified lateral SMASectomy, and suspension of the malar fat methods. After subcutaneous dissection he suspended the malar fat pad to the deep temporal fascia by using a thin suture-passing instrument that penetrates the SMAS in a safe space (anterior third of the zygomatic arch) to avoid subcutaneous suspension suture.

Saylan (103) suspended the platysma and the SMAS to the zygomatic arch periosteum with purse-string-type sutures after an S-shaped short scar and limited subcutaneous dissection. Tonnard et al. (31) later modified his method and introduced it as the minimal access cranial suspension—MACS lift. They performed skin incision between the caudal edge of the earlobe and the sideburn followed by limited subcutaneous dissection in the simple MACS technique. They also suspended the platysma and the SMAS, but in contrast to Saylan they did so to the deep temporal fascia. In the extended MACS technique, they continued the subcutaneous dissection over the malar fat pad, and then suspended this tissue with a third suspension suture (Figure 22).

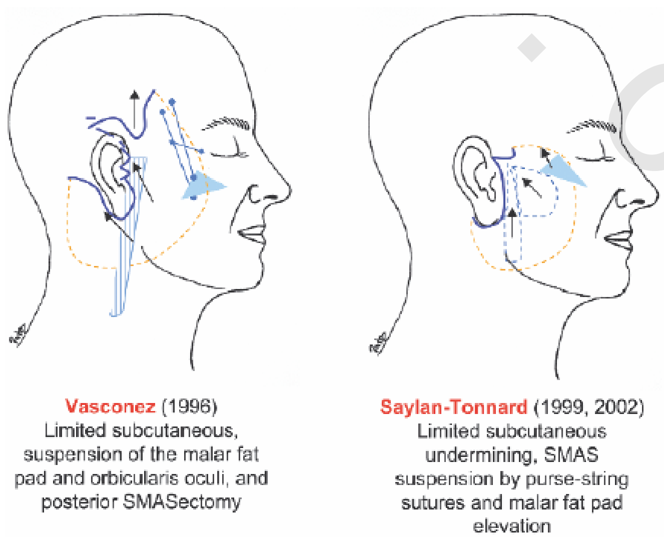

Figure (22): Suspension techniques (69)

The Minimal Access Cranial Suspension (MACS) lifting

When different surgical techniques in plastic surgery and especially in facial rejuvenation surgery are compared, one is tempted to look only at the end result and not at the global risk–benefit ratio that should be considered with any intervention. Some interventions can lead to superb final results but this at the cost of a possibly high complication rate and a long postoperative recovery period. It is not always the most aggressive and extreme surgery that delivers the happiest patient. There is a delicate subjective balance between the final result and the morbidity of the procedure that will determine the degree of the patient's happiness.

In the last decade of the twentieth century, facial aesthetic surgeons became increasingly convinced of the importance of shifting facial volumes rather than putting traction on the skin. The concept of volumetric rejuvenation gained worldwide acceptance. The restoration of facial volumes is more important than the amount of skin resected and the tension on the skin and superficial musculo-aponeurotic system.

All traditional facelift designs have an oblique vector of traction on the SMAS which can be decomposed into a horizontal and a vertical component (Figure 23). The horizontal component of this vector of traction on deep tissues and skin does not really rejuvenate the face. It rather flattens the face and puts it under tension.

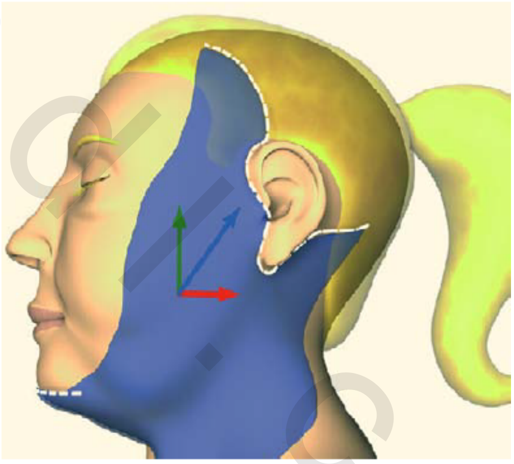

Figure (23): Traditional facelift designs have an oblique vector of traction. (31)

In recent years, more emphasis has been put on reorienting this vector in a more vertical direction. The working hypothesis of minimal access cranial suspension (MACS) lifting is as follows: The only rejuvenating vector applied on the deep tissues as well as on the overlying skin is the vertical one. In the MACS lift the horizontal vector of traction is omitted, making this procedure a pure vertical vector facelift on deep tissues as well as on skin. It is aimed at obtaining antigravitational volume redistribution in the upper neck and face by suspending the soft tissues of the face, working in the superficial subcutaneous plane without any deeper undermining.

The MACS lift is a short scar face lift that elevates the deep tissues and skin using a vertical vector only. Sagging facial soft tissues are suspended with permanent or slowly resorbable purse-string sutures strongly anchored to deep temporal fascia through a preauricular and temporal prehairline incision.

Two variations of the procedure were designed (31):

1. **The simple MACS lift(S-MACS),** where two pursestring sutures are placed for correction of the neck and the lower third of the face (cervicomental angle, jowling, and marionette grooves) (figure 24).

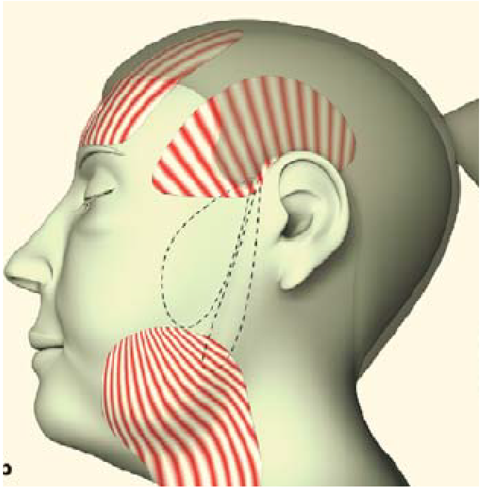

Figure (24): Simple MACS-lift. Position of the vertical, narrow purse-string suture and the 30° wide purse-string on the nonundermined SMAS with anchoring to the deep temporal fascia (31).

2. **The extended MACS lift (E-MACS),** where a supplementary third purse-string suture is placed to suspend the malar fat pad. This suture will have an extra effect on the nasolabial groove, the midface and the lower eyelid (figure 25).

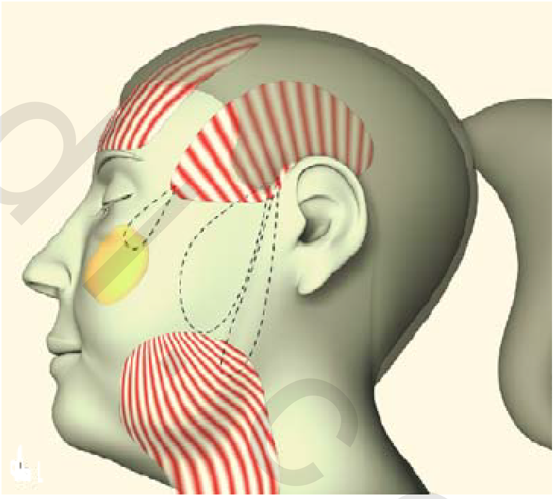

Figure (25): The extended MACS lift. Position of a third narrow pursestring suture, in addition to the two purse-string sutures (31).

In the simple MACS lift, two purse-string sutures are used for correction of the neck, the jowls and the marionette grooves. They are both anchored to the deep temporal fascia above the zygomatic arch 1 cm in front of the auricular helix. The first suture runs as a narrow vertical U-shaped purse string to the region of the mandibular angle catching the lateral border of the platysma muscle. Tying this suture under maximal tension produces a strong vertical pull on the lateral part of the platysma muscle, correcting the cervicomental angle of the neck region, which has been liposuctioned previously. The second purse-string suture starts from the same anchoring point above the zygomatic arch and runs obliquely in the direction of the jowls as a wider O-shaped loop. This suture corrects the jowls, the marionette grooves and the downward slanting of the corners of the mouth (31-104) (Figure 24).

When performing an extended MACS lift, an additional undermining of the skin over the malar region is performed. A point dropped 2 cm below the lateral canthus has been marked with the patient in the standing position. It will be included in the skin undermining and is the inferior limit of the third purse-string suture. This suture originates as well from the deep temporal fascia, but in its anterior part, lateral to the lateral orbital rim. It provides a strong correction of the nasolabial fold, an enhancement of the malar region, a lifting of the midface and a shortening of the vertical height of the lower eyelid (31-104) (Figure 25).

The decision whether to perform a simple or an extended MACS lift is not purely determined by the age of the patient. The main consideration to make is whether the patient needs a correction of the upper half of the nasolabial fold and the midface (104). The third suture, suspending the malar fat pad, gives a powerful correction of these features. It also enhances the volumetric restoration of the midface and provides a very strong support of the lower-eyelid skin. This means that the indication for the third suture can be extended to patients with a flattened malar mound and laxity of the lower eyelids. This is not only determined by age, but also by the facial bony anatomy.

In both the simple MACS lift and the extended MACS lift the skin is redraped in a pure vertical direction and the excess of skin above the temporal hairline incision is resected. As no lateral traction on the skin is applied, there will be no dog-ear at the level of the earlobe, eliminating the need for a retroauricular dissection (Figure 26).

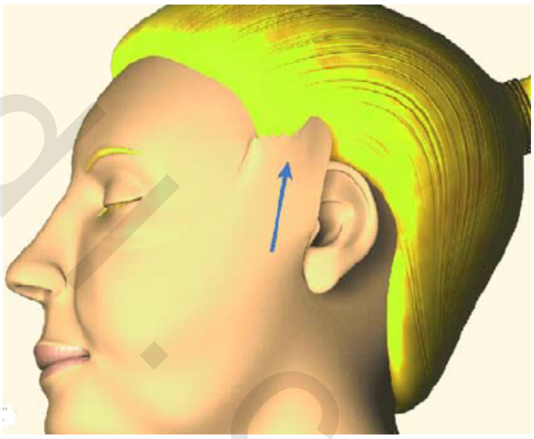

Figure (26): Vertical skin redraping will not produce a dog-ear under the earlobe and will avoid the necessity for retroauricular dissection (31).

The appeal of the MACS lift lies mainly in the fact that it offers a stable and natural facial rejuvenation by a simple and safe procedure of low operative time which can be performed under local or general anaesthesia. In comparison with a classic facelift, the MACS lift has a quicker recovery and a lower morbidity (105). Last but not least the final scar is significantly shorter.

The MACS lift provides a powerful correction of submental and upper-neck laxity, correction of a blunted submental angle, restoration of a well-defined jaw line by correction of the jowls, restoration of the midfacial volume and correction of the nasolabial fold.

Over the years ancillary procedures have been added to the MACS lift to provide a more enhanced facial rejuvenation (105). Liposculpture is now routinely combined with MACS lifting, and the third suture has become a routine addition for patients with midfacial laxity. Because of these additions, indications for the