Nonexcisional, Minimally Invasive Rejuvenation of the Neck

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KEYWORDS

• Noninvasive neck rejuvenation • Laser neck procedures • Radiofrequency neck procedures • Bodytite • NeckTite • FaceTite • Smartlipo • Fractora • Fractional CO2 • RF • Radiofrequency skin resurfacing

KEY POINTS

- This paper describes nonexcisional techniques for neck rejuvenation.
- External and subcutaneous and subdermal laser, RF, light, ultrasound and injectable treatments are reviewed.

***Editor Commentary**: Steve and I have been involved in several emerging technologies and have had the pleasure to discuss alternative and additive modalities with him frequently. In this chapter, Steve takes us on the journey of minimally invasive and non-invasive energy based techniques to rejuvenate the aging neck. He frequently combines these techniques with open aggressive procedures. Realizing that minimally invasive techniques can provide measureable skin tightening has provided yet another opportunity to answer our patients' desires for procedures with a quicker recovery. Of course these can be stand alone procedures or performed along with or following more aggressive surgical maneuvers. The patient with minimal submental and or jowl laxity after a face and necklift looks to us to provide a solution. For sure, we enjoy surgery more than our patients and therein lies their quest for an easy answer without surgical expense and downtime.*

INTRODUCTION

Western civilization is experiencing a "boom in boomers," an aging population, with population decline. The aging population in Western Europe, North America, and Asia has disposable income and the mantra of "youth and vitality" has this generation increasingly presenting for aesthetic treatments, specifically noninvasive or nonexcisional procedures.[1,2] The neck aesthetic subunit often ages early and more noticeably than other head and neck regions and is one of the most common motivations for patients to present to aesthetic physicians for rejuvenation options. The neck undergoes extrinsic and intrinsic aging changes in all anatomic layers and the aesthetic physician must be well equipped to deal with aging cervical concerns, both surgically and nonsurgically. For the surgeon, being skilled in nonsurgical cervical rejuvenation is critical, as many patients may opt for nonexcisional cervical enhancements, alone, or in combination with other facial cosmetic surgical procedures. For the cervical surgeon, a familiarity and expertise with nonsurgical management of the neck, as "stand-alone" therapy or as postoperative "protect your investment" treatments, may help extend and prolong the achievements achieved surgically.

A youthful neck is most often characterized by an acute cervicomental angle and a firm, well-defined jawline (**Fig. 1**). The skin in a youthful neck is smooth and devoid of horizontal or vertical neck lines; has no platysmal bands; no visible submandibular glands; small, nonhypertrophic masseter

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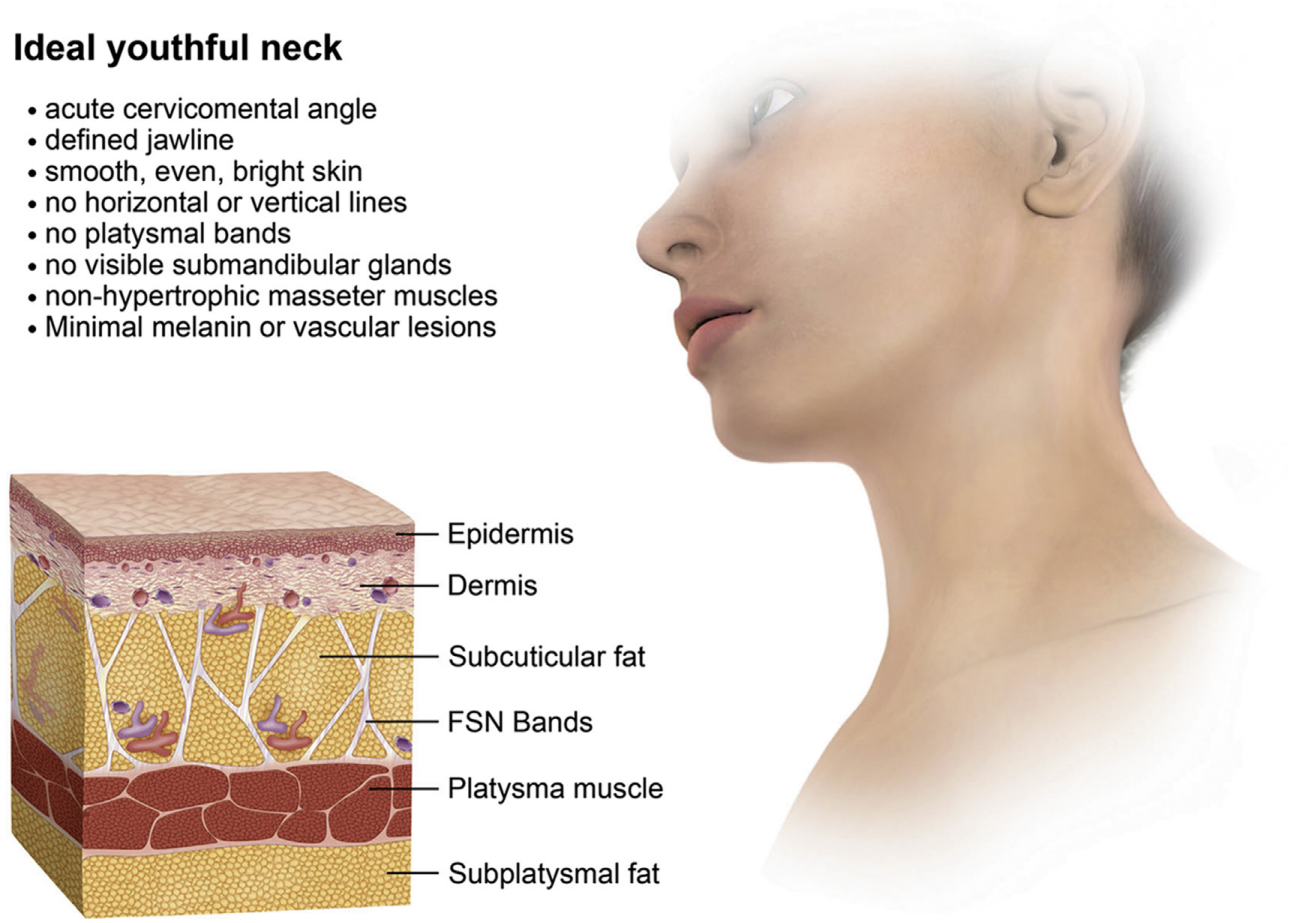

Fig. 1. Characteristics of an ideal youthful neck.

muscles; and skin that is bright and even in color, with minimal melanin or vascular lesions.[3]

For the nonexcisional cervical physician, aesthetic rejuvenation of the neck with a multimodal, nonexcisional, minimally invasive approach will be a very common and popular component of the facial aesthetic practice. For all aesthetic physicians, familiarity with the aging tissue changes of the neck, its anatomy and the possible minimally invasive, nonexcisional interventions, including laser, light, radio frequency, high-intensity focused ultrasound (HIFU) energy-based therapy, both transepidermal and subdermal approaches, injectable soft tissue fillers, neuromodulators, and ablative and nonablative technologies for skin rejuvenation, as well as suture-based suspensory techniques, all used alone or in combination, will be a valuable asset to the global aesthetic head and neck cosmetic physician.

This article brings together the "tried-and-true" nonexcisional neck rejuvenation methodologies, which have had long-term, peer-reviewed success in the literature, together with procedures and technologies that have emerged in the past few years that have proven to be successful and complementary. It is my hope that this information assists aesthetic physicians in enhancing their global approach to nonexcisional rejuvenation of the neck.

AESTHETIC CERVICAL ANATOMY OF THE NECK

This issue of *Clinics in Plastic Surgery* deals extensively with the surgical options and management of the aging neck. However, the noninvasive, minimally invasive and nonexcisional solutions for the neck are often what patients opt for and, many times, are techniques and strategies that can also enhance and/or extend surgical results, or can be applied following surgical neck procedures to provide smaller enhancements and maintenance of the outcome postoperatively.

The aesthetic anatomy of the neck can be divided into several layers, from superficial to deep, starting with the skin, subcutaneous tissue, superficial musculo-facial layer and deep subplatysmal structures (**Fig. 1**).[3] In this section, the relevant anatomy of the neck as it pertains to minimally invasive and noninvasive rejuvenation procedures is outlined and then cervical enhancement options for each layer follow.

The anatomic classification of the neck pertains to the aging structures as the patient sees them

and to the anatomic options and targets that the aesthetic physician may elect to treat, which are outlined in **Fig. 2**.

Cutaneous Cervical Layer

The cutaneous layer of the neck consists of a relatively thin epidermis and dermis. The skin of the neck is subject to multiple mimetic and cervical animations, and tensile and compressive loads. Bending the neck in the anterior-posterior direction, as well as side to side with active contraction of the underlying platysma, can lead to horizontal lines or "necklace lines." The skin ages as a consequence of intrinsic (genetic) and extrinsic (applied) forces. The neck itself is often exposed to the sun and may not be protected by sunscreen and, thus, often presents with significant extrinsic photoaging. Cervical photoaging will result in increased epidermal thickness, degeneration of functional elements of the cervical dermis, such as useful collagen, elastin, and ground substances, with accumulation of whorls of elastotic collagen in the deep dermis (**Fig. 3**). Aging laxity of the platysmal muscle may lead to visible central and/or lateral neck bands. The cumulative photoaging of the neck combined with intrinsic aging and mimetic changes results in a typical aging cutaneous cervical envelope, characterized by thin "crepe" skin, diffuse dyschromia and telangiectasia, with multiple vertical lines in the midline, affectionately termed "iguana neck," as well as horizontal lines, centrally and laterally, attributed to platysma and cervical motion (see **Fig. 3**).

The aesthetic physician needs to be especially skilled in the rejuvenation of the cutaneous layer of the neck. Surgeons performing excisional neck surgery can often fail to deliver optimal neck rejuvenation results by not being familiar with, or equipped to deal with, superficial aging changes of the neck. The superficial cutaneous aging changes to the neck do not respond optimally to pure tensile repositioning characterized by neck lift surgery, but rather, respond to multimodal, noninvasive treatments designed to improve the more superficial color, tone, and texture of the skin. Similarly, nonsurgical aesthetic physicians need to familiarize themselves with the various nonexcisional treatment modalities used to rejuvenate the cutaneous layers of the aging neck.

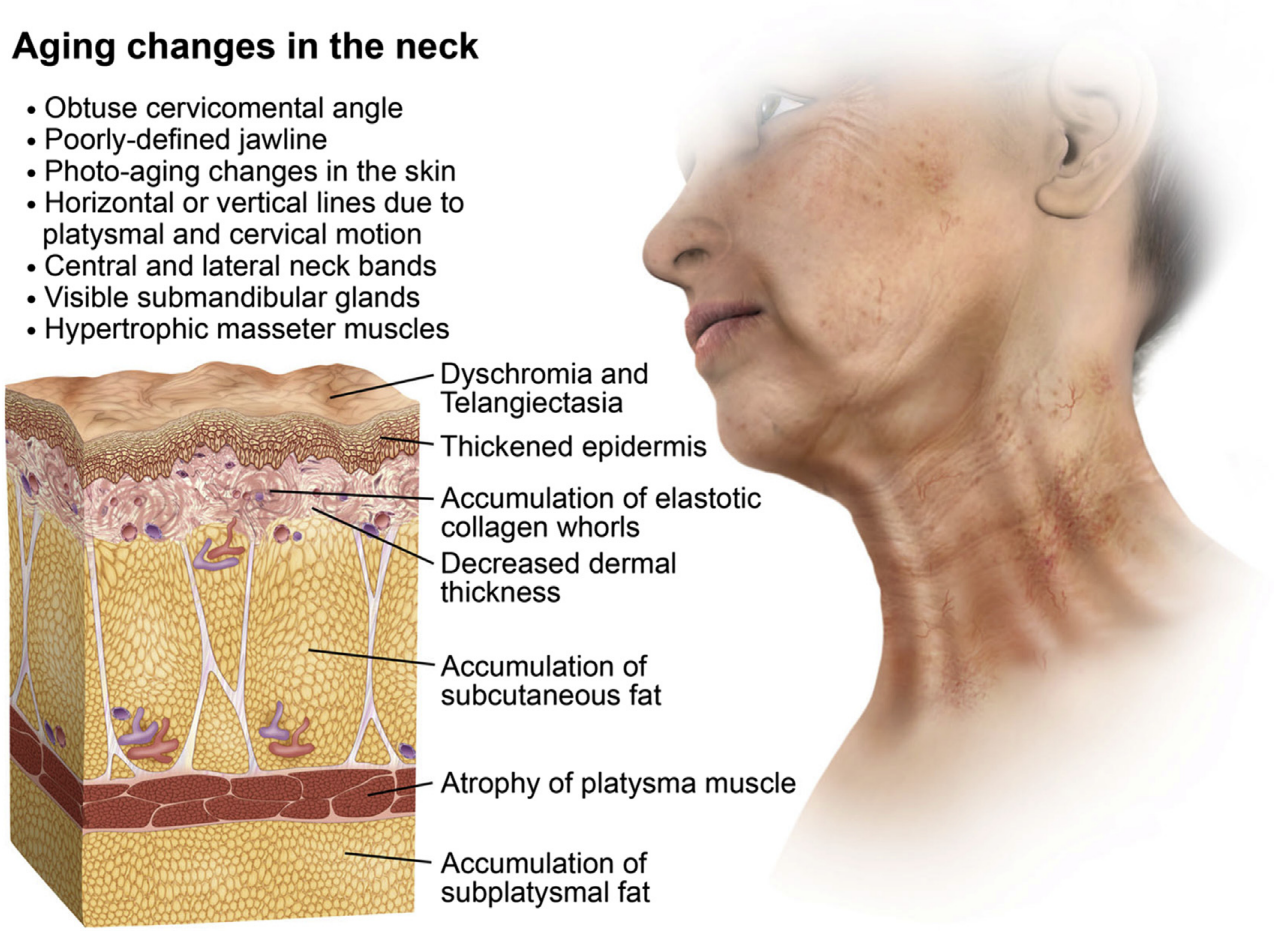

Fig. 2. Anatomic classification of the neck pertaining to the aging structures and to the anatomic options with potential for treatment.

Fig. 3. (*Left*) Cervical photoaging resulting in laxity of the platysmal muscle and thin "crepe" skin, with multiple vertical lines and horizontal lines attributed to platysma and cervical motion. (*Right*) Complete cervical dyschromia correction combined with décolleté provides a natural blend between the rejuvenated neck, the chest, and the face.

Subcutaneous Cervical Layer

Deep to the cutaneous, epidermal-dermal layer of the neck is subcutaneous or adipose tissue. There can be a wide variation in aging presentations of the cervical subcutaneous layer. Some patients have aging cervical phenotypes that have little subcutaneous fat between the deep dermis and the underlying platysma, whereas other patients have extensive amounts of subcutaneous fat between the dermis and the platysma. Modest-to-large amounts of subcutaneous fat will create an obtuse angle to the cervicomental angle and detract from what is considered a youthful neck. An ideal neck consists of a vertical cylinder, the trachea and muscles that connect as a right angle to the floor of the mouth and submandibular tissue, forming a 90° angle (see **Fig. 1**).

Subcutaneous fat of the neck is generally less fibrous than adipose tissue of the trunk or thighs and is a single layer with interlobular fascial components connecting the platysma layer on its deep surface to the dermis. It is imperative that the aesthetic physician be able to diagnose subcutaneous fat, which is preplatysmal, from subplatysmal fat, which will also compromise the acute cervicomental angle, but is more difficult to access and to treat without incisional or excisional surgery.

The Cervical Platysmal Layer

The platysma bands are wide, broad strap-shaped skeletal muscles extending from the clavicle to the dermal attachments along the mandibular border.[3] The cervical platysma is invested by the superficial layer of the deep cervical fascia and will extend superiorly as the superficial-muscular aponeurotic system (SMAS).[3] The platysma comes in a number of anatomic variants, including those with no central diastasis and those with a wide central diastasis that may present as medial platysmal bands. The platysma itself has been attributed the aesthetic function of a secondary depressor of the modiolus, synergetic to the primary depressor of the corner of the mouth, the depressor angularis oris (DAO), and in this fashion, the lateral platysmal bands can act as a depressor of the midface, commissure, mouth, and jawline.[4,5]

The platysma itself, when hypertonic, can lead to distracting aesthetic contours, causing obliquity of the otherwise youthful, acute cervicomental angle (see **Fig. 3**). With aging and muscle flaccidity and atrophy, the platysma bands can contribute to cervical laxity, creating a loose, adynamic, and obtuse neck. The aesthetic physician should be prepared to treat the cervical platysma when it is aesthetically important to the an optimal rejuvenative outcome, and excisional

physicians, in addition to surgical manipulation and excision transection techniques, must also be able to manage nonoperatively any dynamic preoperative and postoperative cervical aesthetic problems.

Subplatysmal Aesthetic Structures

The subplatysmal aesthetic structures that can be treated nonexcisionally or minimally invasively include the densely packed, subplatysmal, adipose tissue that is present in a significant proportion of cervical aesthetic patients, as well as the submandibular glands. The deeply compacted subplatysmal fat lies on top of the mylo-hyoid muscle and may contribute to a "double chin" or obtuse cervicomental angles, and the aesthetic physician needs to be able to diagnose, either by clinical examination or ultrasound techniques, when the submental fat is due to preplatysmal or subplatysmal pathology. Suctioning subplatysmal fat may require a small incisional localization of the platysma to place the cannula in the subplatysmal plane, or open subplatysma lipectomy.

The other deep platysmal structures that occasionally require aesthetic management and nonexcisional treatment are the submandibular glands. The submandibular glands measure approximately 3 × 5 cm and are secondary salivary glands that rest in the lateral floor of the mouth and they can occasionally be visible as lumps or soft tissue shadows in the lateral neck. These glands can be particularly visible postoperatively after tightening or suction reduction procedures of the anterior and lateral neck. Both the excisional and nonexcisional cervical aesthetic physician needs to be able to address prominent submandibular glands (see **Fig. 3**).

ANATOMIC, NONEXCISIONAL MANAGEMENT OF THE NECK

Cutaneous Layer

Chromaphore-based pathologies

Melanin-dyschromia Melanin discoloration, or dyschromia, of the neck is common, given its sun-exposed location on the head and neck region. Commonly patients will neglect to apply sunscreen or sunblock on their cervical region, yet cover the backs of their hands and their face. Over years of sun exposure, the typical photoaging appears. Melanin and dyschromia lesions can range from isolated solar lentigines or diffuse dyschromia and melisma. Diffuse brown discoloration is a very common presentation of the aging neck. Quite frequently, the dyschromia is associated with other signs of photoaging, including thickening and hyperkeratosis of the epidermis layer, thinning dermis with decreased elasticity, decreased functional elastin and collagen, and elastotic whorls of disorganized collagen in the deep reticular dermis associated with fine or deep cervical rhytides (see **Figs. 2** and **3**). The cervical skin will often look vertically fissured or, even further, cobblestoned Fitzpatrick VIII, IX, or X type of rhytids can appear (see **Figs. 2** and **3**). The dyschromia, with or without photoaging is best treated with modalities that are either specific to the discoloration or nonspecific and ablative in nature. Historically, chemical peels of the neck, like complete laser ablative resurfacing, were fraught with potential for wound-healing complications, as the adnexal tissue in the cervical dermis is limited, with few sebaceous glands, pilosebaceous units, eccrine, or apocrine glands to *reepithelialize completely ablated skin*.[6,7] Hence, the use of moderate strength office or home-based topical chemical correction of cervical dyschromia has become popular, with very mild chemical peels or "bleaching agents."[8,9] The bleaching regimens generally consist of combinations of retinoic acids 0.05% to 0.1%, or tazarotene 0.025% to 0.01%, alone or combined with hydroquinone 4%, 6%, or 8%, 4% Kogic acids, and occasionally mild hydrocortisone-compounded substances. Prescriptive skin bleaching programs include the popular Tri-Luma. Other skin care regimens, such as Obagi, SkinCeuticals, Physician Choice of Arizona, Skin Medica, and others, have been quite popular in gradually bleaching dyschromia of the neck using home-based programs. Office-based treatments include stronger chemical peels, although the risk of delayed *reepithelialization* and hypopigmentation or hyperpigmentation is greater when stronger preparations of glycolic, glycolic acid, trichloroacetic acid, or stronger topical chemical ablatives are deployed.

Over the past 15 years, chromophore-based lasers and light-based sources have become the mainstay of skin color correction and are arguably the gold standard of dyschromia-associated aging of the neck. Chromophore-based lasers and light-based systems have wavelengths of light that are specifically attracted to intra-epidermal, epidermal-dermal, and superficial dermal melanin, through a process called selective photothermolysis.[10] Typically, wavelengths in the range of 500 to 800 nm will have some increased affinity for and selective absorption of superficial cervical melanin-based concerns. Some of the monochromatic focal wavelengths for the improvement of superficial epidermal-dermal melanin include the 532-nm wavelength Potassium titanyl phosphate (KTP) lasers, 694.5 nm Q-switched Ruby, and the 755 long-pulsed or Q-switched Alexandrite lasers, which have all been deployed in specific correction

of dyschromia of the neck.[11–13] Pulsed dye lasers in the 585-nm wavelength have also been deployed to treat not only vascular lesions but pigmented lesions of the neck.[12] However, the one most popular light-based rejuvenation of the neck for dyschromia and vascular chromophores has become intense pulsed light, or IPL.[14,15] IPL, broad-band flash lamps, or xenon flash lamps consist of visible wavelengths of light from 500 nm to 1200 nm all released during the same pulse. Specific cutoff filters are deployed in a variety of methods, with or without direct water cooling, interpositional gel, or air cooling in a multitude of intense pulsed light systems available on the market to treat very effectively melanin and vascular discoloration of the cervical skin. Generally, for cervical rejuvenation in skin types I, II, and III, with dyschromia, cutoff filters in the 515-nm to 580-nm range have been very successful.[14,15] For skin types 4 and 5, long wavelength cutoff filters in the 590-nm to 640-nm ranges, lower energies, and longer pulse configurations have allowed the treatment of darker discoloration in patients with more advanced Fitzpatrick skin type.[16] Using gentle energy with broad melanin absorption coefficients and overlapping 20% or so, each pulse can provide safe, effective clearance for even the most severe cervical dyschromia over several sessions.

Intense pulsed light treatments of the neck usually require 1 treatment every 3 to 4 weeks for a total of 3 to 5 treatments. It can be quite common to cause striping in the neck following early IPL therapy in patients with extensive photoaging, which is caused by a combination of aggressive settings and not overlapping the light guide sufficiently during each treatment, which results in aggressive fading of the treated neck adjacent to untreated skin that does not fade in color. Gentle settings, multiple sessions, and overlapping or crisscrossing can avoid this problem. It is important that the IPL settings are gentle moderate in fluence, as IPL may induce a permanent hypopigmentation or discoloration of the skin.[13–15] Monochromatic treatment of the neck with focal monochromatic laser systems can cause a reticulated hypopigmented appearance to the cervical skin.[13]

It is common in dyschromia and photoaging of the skin to have a relative white and protected area of skin color immediately under the chin and submentum superior to the hyoid cartilage. This "white patch" represents the shaded area naturally created by the projected pogonion of the mandible. It is important to try to blend the "white under chin" into the more dyschromic and photoaged, lateral, and inferior aspects of the neck. It is also important to blend the discoloration of the central and lateral neck into the posterior triangle and trapezius border. Additionally, carrying the treatment over the clavicle onto the precordial region will help minimize risk of demarcation between a treated neck and an untreated décolleté. Often, combining complete cervical dyschromia correction with décolleté will provide a natural blend between the rejuvenated neck, the chest, and the face (see **Fig. 3**).

The recent addition of fractional nonablative, fractional ablative lasers, and ablative fractional radiofrequency devices has also provided an opportunity to improve dyschromia and photoaging, as well as fine lines and texture of the neck.[17–24] Although intense pulsed light and other monochromatic melanin-based wavelengths of light are very effective for brown and red "color correction," they have little effect on fine rhytides and wrinkles and the use of ablative fractional carbon dioxide lasers, and, to a lesser extent, ablative fractional and nonfractional erbium lasers can have the simultaneous benefit of decreasing the dyschromia and improving fine lines, rhytides, and laxity.[17–24] More recently, fractional radiofrequency devices, such as the Fractora (Invasix, Yokneam, Israel), have become available, which can provide variable depth and variable density needle-based tips for fractional ablative improvement of the dyschromia of the neck, as well as the textural improvements that can be equivalent to those achieved with carbon dioxide.[25] At the same time, the Fractora delivers a nonablative, non-necrotic tightening of the cervical region. The Fractora delivers radiofrequency energy and a positive charge along each of the pins in the needle array, resulting in an ablative crater and a zone of nonablative, but irreversible, thermal coagulation. Following the ablative injury, the radiofrequency (RF) energy then flows from the tip of the pin to the negative side electrode, creating a rich woven network of nonablative RF dermal heating, tightening, and remodeling (**Figs. 4–6**).[25]

Complications of the management of melanin and dyschromia of the neck include scars from overzealous laser and light-based settings, hypopigmentation from aggressive settings that result in a complete or near-complete clearance of melanocytes, as well as demarcation from treated and untreated areas.[6] Quite often, clinically, dyschromia occurs together with vascular discoloration, such as in Poikiloderma of Civatte, which is covered in the next section.

Vascular or hemoglobin-based cervical rejuvenation In addition to dyschromia and melanin-based lesions, it is quite common to get superficial vascular proliferation as a part of extrinsic photoaging or intrinsic genetic aging of

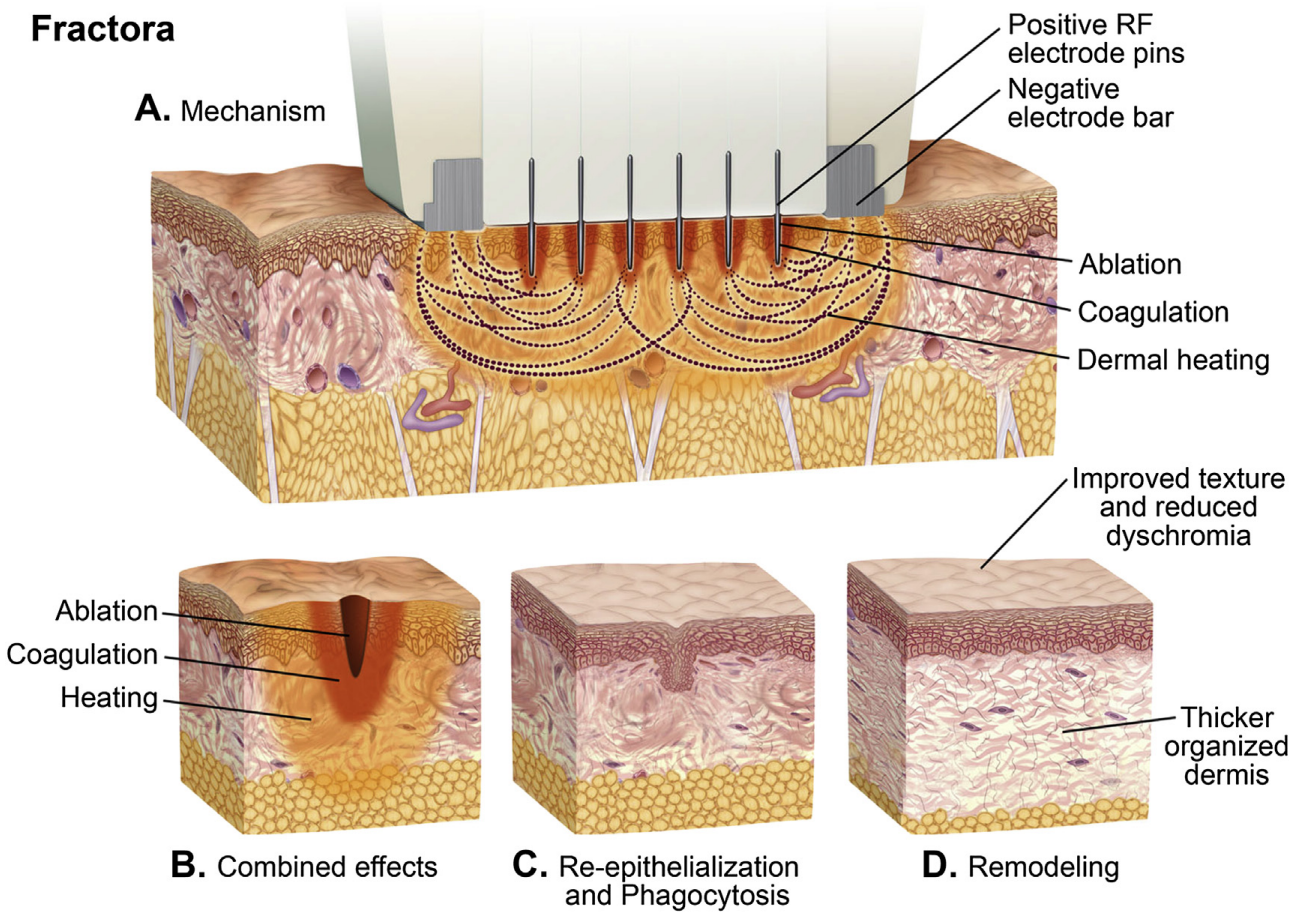

Fig. 4. Fractora fractional radiofrequency resurfacing (*A*) showing the ablative crater and zone of non-ablative irreversible coagulation (*B*), re-epithelialization (*C*) and remodeling (*D*).

the neck. The vascular proliferation derived from photoaging responds very nicely to the intense pulsed light with the same cutoff filter spectrum mentioned in the dyschromia section.[11,14,15] Occasionally, deep dermal and subdermal, proliferative vascular lesions occur in the neck and monochromatic long-pulse or variable pulsed wavelengths, such as long-pulsed neodymium-YAG or short-pulse and long-pulse, pulsed dye lasers are required.[12] The combination of reticulated hyperpigmentation and vascular proliferation in the upper papillary and mid-dermis condition, called "Poikiloderma of Civatte," is more common in the lateral part of the neck than centrally. This "red neck syndrome" is often treated effectively with intense pulsed light, and peer-reviewed studies showing the successful use of a pulsed dye laser for this condition have been reported.[11–15] One of the complications of the treatment of vascular proliferation in the cervical region with monochromatic high-fluence, short-pulse duration lasers is only variable clearance of the

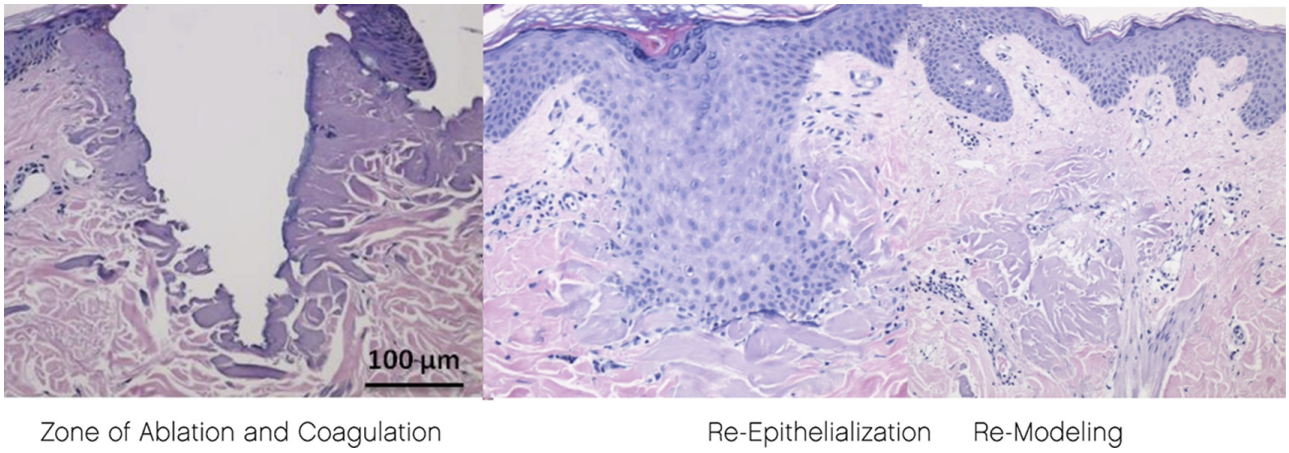

Fig. 5. High power histology showing fractora fractional RF ablative injury, with re-epithelialization and remodeling.

Fig. 6. The family of variable length and variable density Fractora tips.

reticulated hypopigmentation, leading to a partially white, "spotted leopard" look to the skin.[11–15] Intense pulsed light used gently over several sessions is often the best modality to blend most evenly the vascular as well as the melanin discoloration in the neck.

Epidermal and dermal nonchromophore-based lesions

There are many nonchromophore-based aging pathologies of the cervical skin that must be addressed to achieve the optimal outcome for youthful neck rejuvenation. Procedures such as simple shave excision, chemical or thermal ablation of intra-epidermal papillomas, skin tags, compound moles, seborrheic keratosis, actinic keratosis, and a host of other pathologies can significantly improve the appearance of the neck (see **Fig. 6**). Superficial and deep dermal-epidermal rhytides can now be treated "off face" safely and effectively with fractional ablative lasers, CO2, Erbium, and fractional radiofrequency ablative systems (**Fig. 7**).[22–25]

Dermal and Subdermal Tightening Devices and Technologies

There has been a rapid evolution in our ability to provide moderate, nonexcisional skin tightening and wrinkle-reduction therapy with transepidermal energy devices. These new "energy-assisted" nonexcisional skin tightening procedures have become very important drivers of consumer interest, so it is critical that the aesthetic physician have a nonsurgical approach to cervical skin tightening. The first generation of the noninvasive skin-tightening technologies involved nonfractionated longer wavelength near infra-red laser devices, such as the 1320-nm Cooltouch (Roseville, CA), the 1440-nm Smoothbeam (Syneron Candela,

Fig. 7. Cervical rejuvenation with combined sub-dermal heating with Facetite for tightening, IPL for color correction, fractional RF ablative resurfacing for texture and CO2 shave excision of raised dermal and epidermal lesions.

Yokneam, Israel), the long-pulsed Nd:YAG, and the 1320 to 1440 nm synchronously pulsed Affirm MPX (Cynosure, Westford, MA).[26,27] The launch of externally applied RF devices provides the aesthetic physician with one of the most efficient "bulk heaters" of the dermis.[26–29]

Monopolar, stamping RF is typified by Thermage (Solta Medical, Hayward, CA), a very successful device with modest to good skin-tightening effects, proven in large multicentered trials.[28–35] Monopolar thermage protocols for treatment of the neck often includes 2 to 3 passes and 2 to 3 treatment sessions separated by several weeks. Combined optical-bipolar RF devices emerged, such as the Refirm and Polaris (Syneron), showing noticeable improvements using multiple-pass, multiple-session treatment protocols.[30–32] These mono-polar and bipolar RF or optical-RF combination devices, are "stamping" or "static" in nature and often suffer from inadequate dermal stimulation by a combination of very high peak dermal energy (and hence stimulation) but a very short pulse duration, exposing dermal tissue to a relatively short thermal stimulation that would be required for the production of new collagen, elastin, and ground substances. These stamping devices generally deploy protocols with multiple passes and multiple treatments to overcome the ultrashort pulse duration but high temperature model of collagen production stimulation.

More recently, a whole class of transepidermal RF heating devices have emerged that are not short-pulse duration "static" or stamping in nature, but rather, are continuous wave RF systems that are constantly moved along the surface of the skin along a thin layer of ultrasound or some interface gel. The advantage of these "moving" or "dynamic" RF systems is the ability to heat this tissue to a lower temperature but for a much longer period than pulsed mode stamping technologies and, depending on the "moving" device, the therapeutic thermal end point, usually 42°C to 43°C can be maintained, for a very long time. Some of the early "moving RF systems" include the Accent (Alma lasers, Buffalo Grove, IL), Tripolar (Polagen), the diamond polar and Octapolar (Venus Freeze [Venus Concept, Toronto, Canada]), the Excelis (BLT Industries Inc, Framingham, MA), and the 14 and 36 moving bipolar thermally controlled and modulated RF device, called the FORMA (Invasix).[35–44] The FORMA is a very high tech, thermally modulated enhanced moving RF heating device that has built within the hand piece sensors that measure high and low dermal impedance, epidermal temperature, and electrode contact 10 times every millisecond, and automatically adjusts RF energy depending on the sensory feedback. The FORMA will automatically cut the RF energy off when the therapeutic skin temperature is reached, the impedance drops too quickly (temperature is rising too quickly), or the electrodes lose contact with the epidermal surface.[43,44] Once the epidermis cools to 0.1°C below the target temperature, the RF energy is turned on again and heating resumes. The FORMA can read, modulate, and automate the high and low temperature extremes, keeping the skin at a very uniform and consistent thermal end point, usually 42° to 43° for prolonged periods of time by this process of thermal modulation and eliminating the "hot spots" that can cause patient discomfort and burns.[43,44] This thermomodulation process is called ACE, or *acquire, control, and extend*. The FORMA acquires the dermal-epidermal impedance, contact, and temperature information and will modulate the RF on and off, allowing the patient to experience a long, uniform, and comfortable period at the thermal end point (**Fig. 8**). As the thermal control is so exquisite, the patient rarely feels a thermal "hot spot" above 42° to 43° and the device burns can be greatly minimized and diminished. Clinical and histologic studies using ACE RF devices have shown good contraction and 14% more new collagen, and 35% collagen synthesis up-regulation.[44]

Over the past few years, fractional deep dermal ablative devices have been released and commercialized that can result in significant cervical skin rejuvenation. Ulthera, or fractional HIFU, uses high-frequency focused ultrasound to create ultrasound-induced fractional thermal ablative zones in the deep dermis and, in some areas, the superficial aponeurotic system. Results can be excellent, but occasionally painful and inconsistent.[45,46] The HIFU can be combined with IPL or other fractional ablative devices at the same session. Deep RF ablative needle devices are also commercially available, the ePrime (Syneron, Yokenim, Israel) uses an array of 6 bipolar, long silicon-coated RF-emitting needles inserted under local anesthesia to create deep microthermal ablative RF zones that result in remodeling and tightening, while sparing the epidermis. The Fractora family of applicators are available in different lengths and densities, with or without proximal silicone coating (**Fig. 9**). The 3000-μm pin tip (silicon coated or uncoated), alone or in combination with other more superficial Fractora high-density tips, can provide both ablative and nonablative tightening in the deep reticular and superficial papillary dermis. There is also a fractional RF resurfacing Fractora tip with 3000-μm pins that are coated with silicone proximally, to eliminate superficial

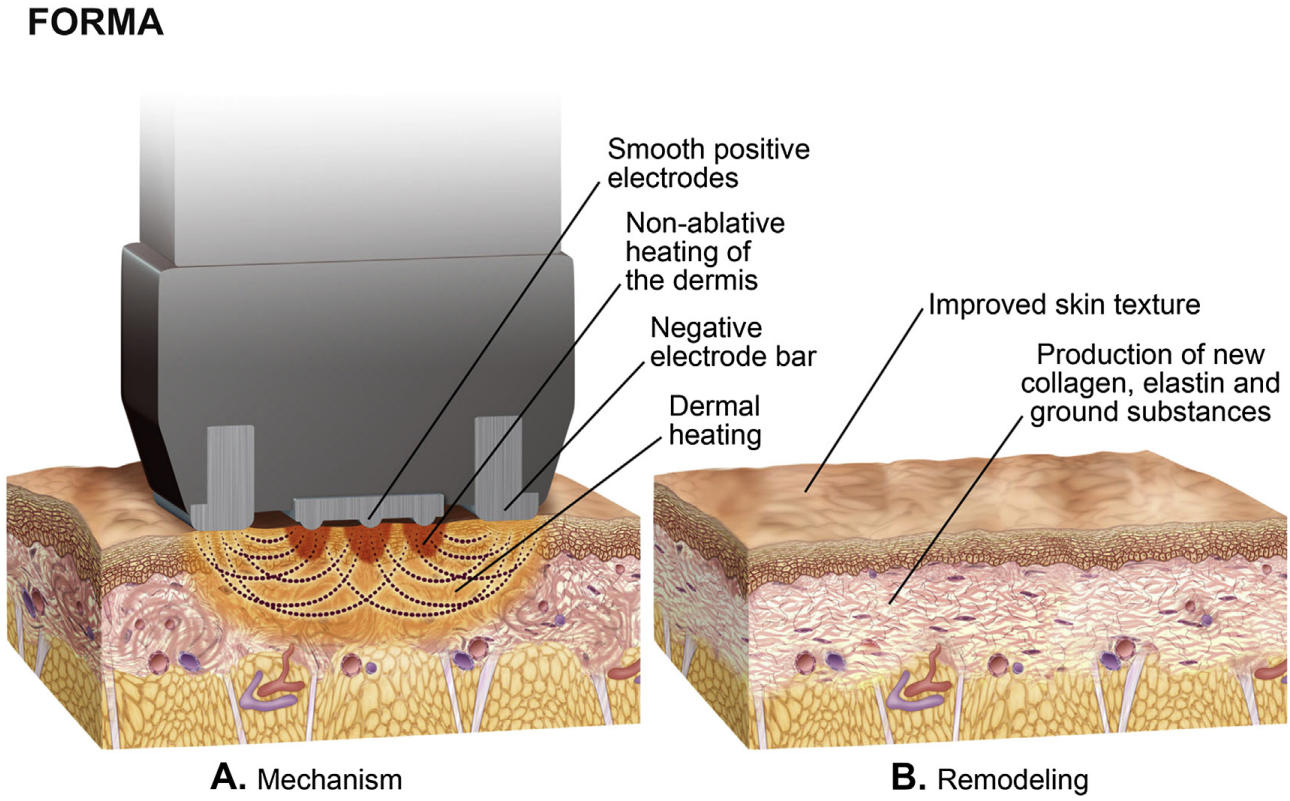

Fig. 8. The FORMA dynamic, non-ablative RF heating of the dermis. The FORMA uses sensors and feedback to continuously modulate the RF delivery dependent upon the measured epidermal temperature, high and low dermal impedance and contact sensing. The non-ablative heating, over a series of treatments results in 35% up-regulation of collagen synthesis and 14% more dermal collagen.

thermal stimulation and the epidermal risk of post-inflammatory hyperpigmentation, while delivering a selective deep dermal texture enhancement and skin-tightening effect (see **Fig. 9**; **Figs. 10** and **11**).

The 24-pin, 3000-μm silicon-coated tip, also called the Fractora Lift tip, is one of the more profound tightening fractional RF applications. The proximal 2000-μm silicone coating facilitates a selective deep dermal RF thermal ablation and nonablative coagulation (see **Fig. 10**). The 24-pin configuration and silicone coating offer a new generation of *bifractional stimulation*, horizontal and vertical fractionation. RF, being an efficient bulk heating energy, facilitates deep tissue remodeling without superficial thermal damage (see **Fig. 11**) The Fractora Lift tip can be used with various energies and multiple passes to result in tissue tightening of the brow, upper and lower lids, cheek, jawline, and neck, as well as deep line reduction and acne scar improvement. The silicone-coated tips can also be used off face. The Intracel, a fractional RF needle device, also uses silicone coating on its RF-emitting needles with variable energy and variable depth capability. The skin-tightening results of the these fractionated, vertical HIFU, or RF systems can be excellent to good, with, in general, one maintenance treatment every 3 to 6 months to "protect the tightening" investment.[43–46] Thermally modulated nonablative skin-tightening applicators also can be used safely off the face and in combination with any other injectables and chromophore-based laser systems of fractional, ablative RF or laser systems.

The Subcutaneous Cervical Layer

Preplatysmal fat

Excessive preplatysmal fat will often compromise a youthful, acute cervicomental angle. There have been a myriad of ways developed over the past 30 years to address submental adiposity in a minimally invasive fashion. Suction-assisted lipoplasty (SAL), has been deployed for 3 decades to remove subcutaneous, preplatysmal fat and, hence, improve an oblique cervicomental angle and create a more youthful acute cervicomental angle.[47–51] SAL is still an excellent technique, particularly in those patients who have good skin tone and elasticity. SAL cannulas range from small, blunt, Mercedes-tipped cannulas, with vented ports, to flat spatula cannulas for separating the subdermal space from the preplatysmal subcutaneous tissue. Evidence exists that subdermal stimulation of the submental skin will likely improve skin contraction, but documented

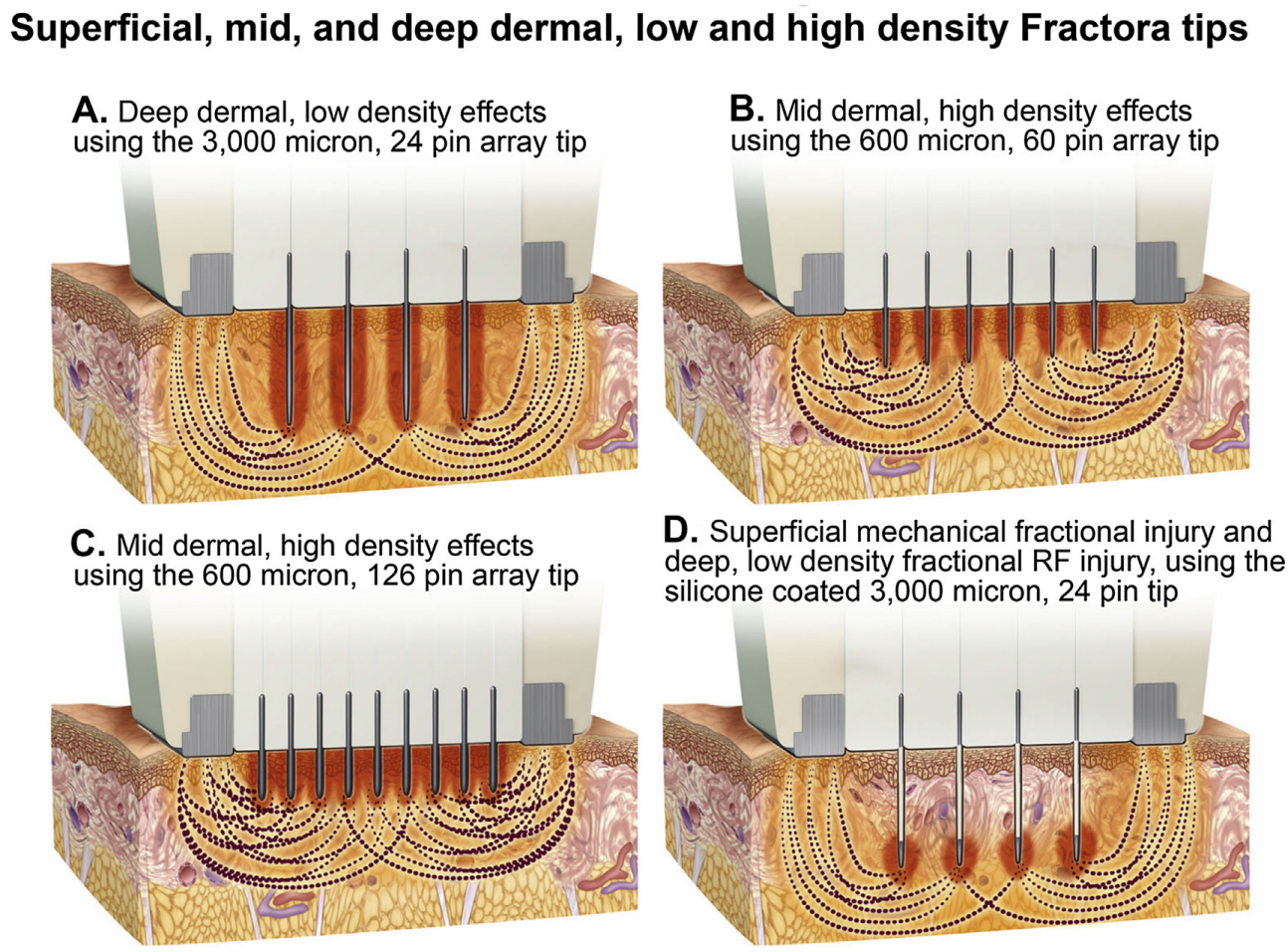

Fig. 9. The family of Fractora RF fractional resurfacing tip including the deep resurfacing 3000 micron tip (*A*), the mid-dermal low density 60 pin (*B*) and high density 126 pin (*C*) and the surface sparing bifractional silicone coated, 24 pin, 3000 micron Tip (*D*).

post-SAL retraction has generally ranged between 6% and 10% at 1 year postoperatively.[51–53]

To minimize ecchymosis and bruising, the introduction of ultrasound-assisted lipoplasty (UAL) in the 1990s brought a new option to the minimally invasive management of cervicomental contouring. Ultrasonic cavitation (streaming of fat cells) minimizes trauma to the subcutaneous vascular network, minimizing bruising, swelling, and pain and optimizing a speedy postoperative recovery.[54–56] There are numerous articles that support the gentle nature of a UAL, and the Vaser from Sound Surgical (Solta Medical, Hayward, CA) is one the world's leading companies in this space. The incisional approach for UAL, like SAL is traditionally a submental stab incision, although for excess subcutaneous preplatysmal lateral adiposity, sublobular stab incision

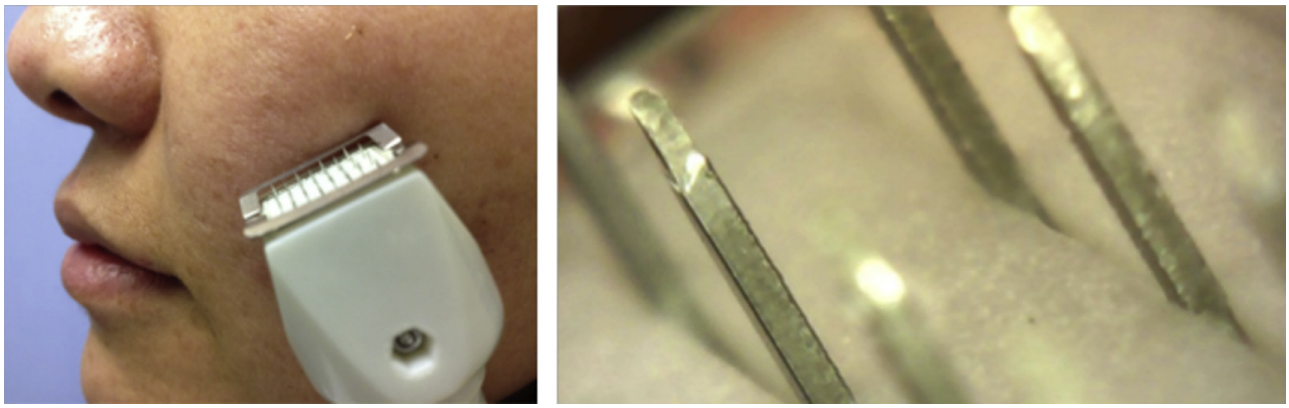

Fig. 10. The Fractora 24-pin, 3000 micron silicon-coated tip for deep dermal tightening with epidermal-dermal thermal sparing.

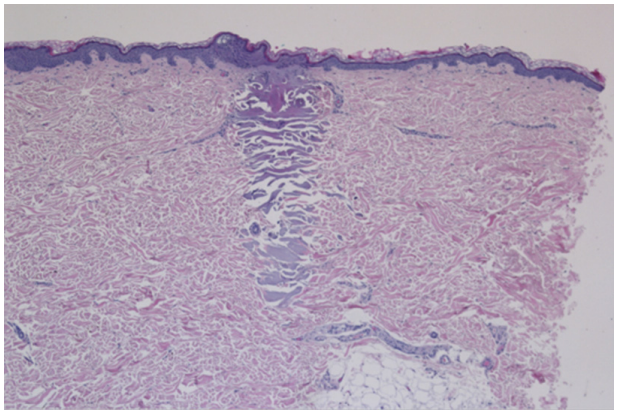

Fig. 11. High power histology showing the Fractora silicon-coated needle tissue effect with a non-ablative penetrating trauma superficially and a deep dermal thermal fractional injury with a superficial thermal sparing effect.

approaches have also been described and can be deployed.[54–56]

The challenge with SAL and UAL comes when a patient has some submental adiposity combined with skin laxity, decreased elasticity, and diminished elastic recoil. Patients with a large, modest, or even minor amount of fat, with poor skin tone, generally do not respond optimally to SAL or UAL, as the contraction is only a moderate 6% to 10%, even with strong, superficial, subdermal stimulation.[51–53] Many surgeons stand by their conviction and ability to stimulate the subdermal space with a nonthermal cannula achieving anecdotal reports of significant tightening; however, the experimental evidence of demonstrable skin contraction, with nonthermal superficial subdermal techniques, usually is reported to be in the 6% to 10% contraction range, when measured over 6 to 12 months.[50–52]

Increasingly, evidence-based medicine has shown that thermal techniques, both in the subcutaneous layer and in the subdermal layer, will lead to enhanced contraction well over and above those achieved with nonthermal, SAL and even UAL techniques.[52,53,57,58] One of the most popular and common options for submental, subdermal, and subcutaneous contouring is laser-assisted lipolysis (LAL).[52,53,57] Smartlipo, by Cynosure, is the world leader in this subdermal laser thermal stimulation market and there are published studies that show that raising the subdermal temperature to 50°C to 55°C, while keeping the epidermal temperatures under 40°C to 45°C, will achieve a 17% area soft tissue skin contraction over 3 to 6 months.[52,53] In addition, subdermal laser heating, to thermal end points, will result in increased dermal thickening of up to 25%, resulting from neo-collagenesis, as well as increased elasticity in the skin of 24%.[52]

The Smartlipo product, as well as other light laser lipolysis systems by other companies (SlimLipo by Palomar [Cynosure, Westford, MA], CoolLipo by CoolTouch [Roseville, CA], ProLipo by Sciton [Palo Alto, CA], and LipoLite by Syneron) all deploy a myriad of wavelengths: the 1440, 1320, and 1064 triplex by Cynosure; the 1320 by CoolTouch; the 1320 and 1064 by Sciton; the 1064 by Syneron; and the 924 and 967-nm diodes by Palomar. The various wavelengths in LAL are attracted to the water in the interstitial fluid created by the tumescent anesthetic technique and secondary cavitation of the tumescent fluid results in the thermal and non-thermal destruction and coagulation of the fat making for a less traumatic aspirate with decreased ecchymosis compared with SAL.[52,53] However, the principal goal of LAL is to induce the enhanced area contraction required by cervicomental skin that is lax. The use of the 1440 and 1320 laser subdermally, as well as the 927 and 968 diode, will induce a thermal stimulation. This thermal stimulation results in a deep reticular dermal collagen denaturization and the neo-collagenesis of the deep reticular layer and enhanced contraction.[52,53]

The use of subdermal LAL can be combined simultaneously and synchronously with transepidermal fractional ablative technologies. The fractional ablative lasers or fractional RF resurfacing devices can be deployed at relatively conservative energy levels synchronously with subdermal thermal techniques to induce a transepidermal fractional rejuvenation and tightening of the cervical soft tissue following the subdermal laser stimulation and aspiration. The fractional ablative lasers can be used alone for cervical texture and dyschromia therapy or in combination with cervical subdermal thermal techniques.

One of the newest and more compelling minimally invasive soft tissue tightening techniques of the neck is subcutaneous and subdermal RF-assisted lipocontouring (RFAL) (Invasix).[59–70] The Facetite applicator deploys a small, silicon-coated, 1.8-mm diameter, 13-cm long, solid RF-emitting probe with a bullet-shaped plastic tip to avoid subdermal "end hit" thermal injuries.[69] The FaceTite is a bipolar applicator with the internal and external electrodes and connected the by the hand piece. The RF current flows up from the internal to the external electrode, which glides along the epidermal surface in tandem with the RF-emitting internal electrode (**Figs. 12–14**). The FaceTite hand piece is connected to a console containing the RF card, electronics, and a central processing unit (CPU). The RF-emitting internal subdermal electrode coagulates subcutaneous fat in close proximity to the electrode in the

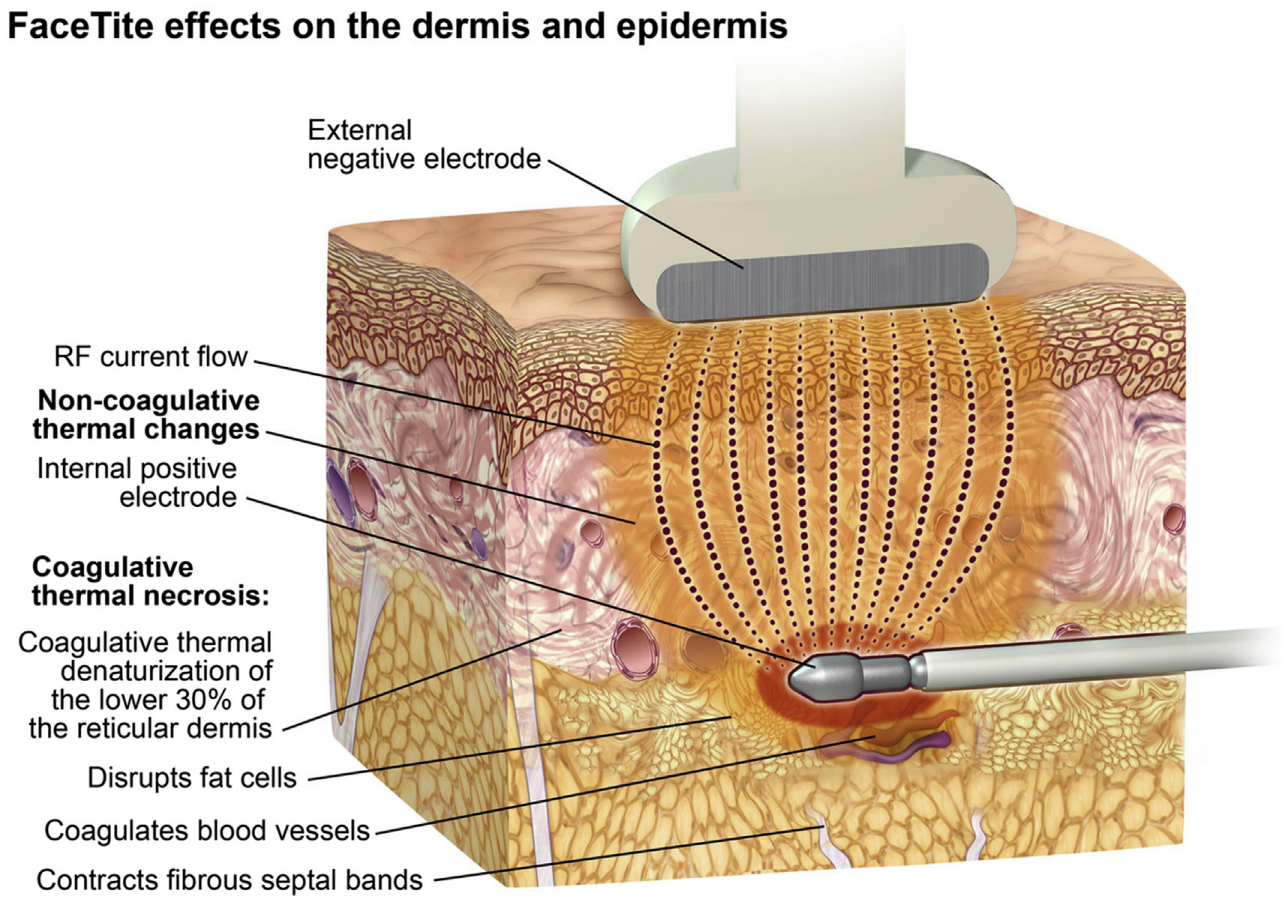

Fig. 12. The FaceTite effect on the dermal and sub-dermal tissues coagulation of the immediate sub-dermal adipose tissue coagulation and then de-naturization.

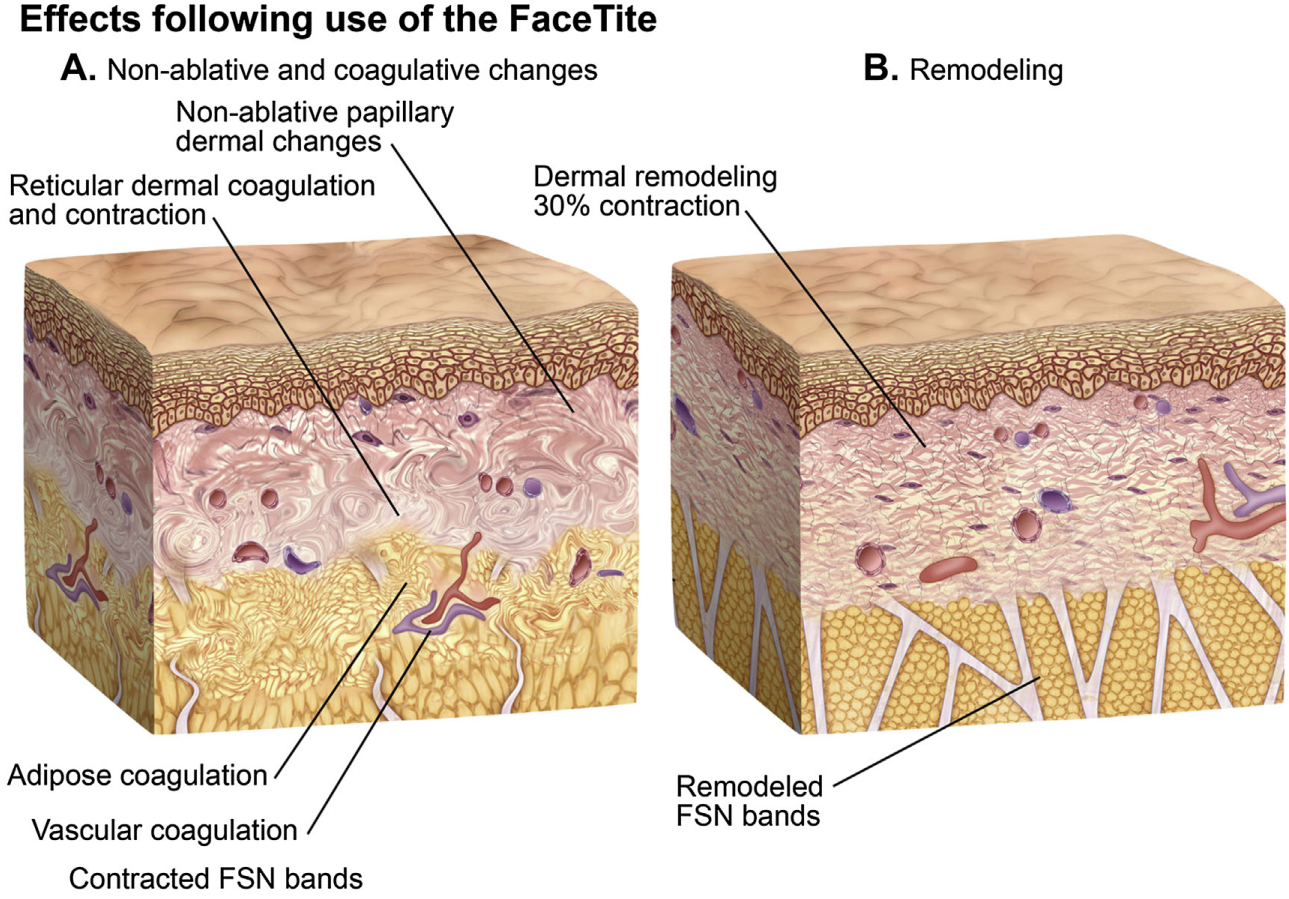

Fig. 13. The FaceTite soft tissue effects with re-orientation of the immediate sub-dermal FSN and direct deep reticular dermal neo-collagensis re-modelling.

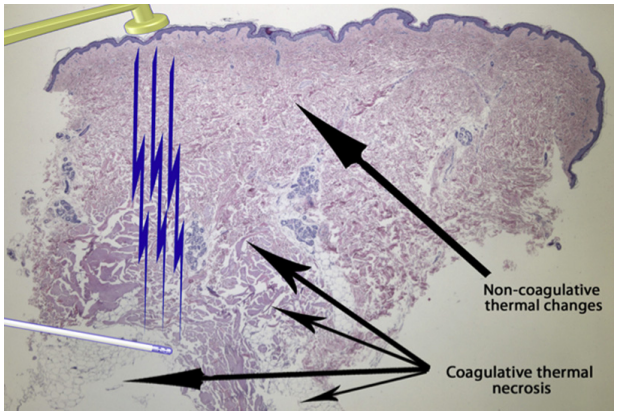

Fig. 14. Coagulative thermal changes.

superficial subdermal space and, as RF energy moves up to the external electrode, it dissipates and gently heats the papillary dermis. The coagulative heat of the subdermal fat results in a thermal denaturing of the reticular dermis, with preservation of the papillary dermis (see **Figs. 12–14**). The external electrode also contains a series of sensors that relay information to the console and CPU that can, in turn, respond by turning on or off the RF energy, modulating the thermal soft tissue exposure. The intricate and exquisite safety features of the FaceTite include high and low soft tissue impedance sensors, as well as epidermal contact sensors and an epidermal thermal sensor. This array of FaceTite safety sensors is able to detect rapidly rising dermal temperatures corresponding to rapidly dropping tissue impedance and are able to turn off the RF energy when these conditions approach empirically dangerous thermal levels. In addition, epidermal temperature is monitored and sampled 10 times per millisecond and the RF energy is turned off when the selected therapeutic end point is achieved. An epidermal temperature of 40° to 42° and a coagulative subdermal thermal exposure is the common end point. When the temperature of the epidermis decreases to 0.1°C below the target epidermal temperature, the RF energy is again turned on, much like an air-conditioning unit in the home and a constant subdermal temperature can be maintained.

This RFAL constantly modulated thermal system and internal impedance-monitoring process is called "ACE," whereby the RF device "*Acquires*" through sensors important information, such as low and high soft tissue impedance and contact and thermal temperature, allows the user to "*Control*" that soft tissue thermal exposure by an automated thermal modulation of the delivery of RF energy as the safe end points are met, and thus facilitating the user to "*Extend*" exposure of therapeutic soft tissue temperatures (hence, ACE, or Acquire-Control-Extend).

The safe, prolonged exposure of the subdermal tissue to heat, is predicated on the assumption that if heat tightens tissue, then optimal exposure and duration to therapeutic temperatures will optimize soft tissue contraction and tightening. Published RFAL articles on soft tissue contraction generally have shown up to a 25% area contraction at 6 months and 35–40% achieved at 1 year.[59–70] The 35–40% RFAL area contraction achieved at 12 months will often facilitate successful treatment and aesthetic outcomes in patients who might otherwise require an excisional neck procedure to have a closed neck procedure with aesthetically pleasing soft tissue contraction (**Fig. 15**).[62,68]

Another useful cervicomental RFAL applicator is called the NeckTite. The NeckTite (Invasix, Yokinem, Israel) is a larger 2.4-mm hollow, silicon-coated internal electrode, again connected to a similar external electrode that senses impedance, contact, and epidermal thermal monitoring. The NeckTite differs from FaceTite in that it synchronously coagulates and aspirates fat as well as heats, and for those patients who have large subcutaneous, preplatysmal adiposity, NeckTite can be deployed to provide the cervicomental contouring with reduction of adipose tissue (see **Fig. 15**). Depending on the laxity and elasticity of the cervical soft tissue, NeckTite can then be followed by a subdermal FaceTite applicator for enhanced dermal contraction (see **Fig. 15**). The NeckTite and its thermal stimulation relies on contraction of the adipose FSN (fibroseptal network) for contraction and, again, significant area contractions of 25% to 40% have been reported over 1 year, attesting to its ability to control soft tissue laxity more effectively than SAL or UAL (**Fig. 16**).[59–70]

Synchronous deployment of fractional ablative laser techniques on the epidermal-dermal surface immediately following subcutaneous and subdermal RFAL thermal stimulation will also induce additive contraction and textural and chromophore improvements. Alternatively, variable depth and density ablative fractional RF resurfacing therapy can be performed on the same session as subdermal RF (FaceTite) or laser thermal stimulation for an inside-outside dermal stimulation, with or without NeckTite stimulation of the deeper fat and FSN (**Fig. 17**).

Fractora deploys fractional ablative RF-emitting needles of various depths and densities that emit a fractional ablative energy that flows from the ablative craters to the negative charged side electrodes, creating a synchronous ablative skin injury and then a nonablative RF tightening as the RF current flows from the tip of the needle and

Fig. 15. Cervicomental contouring and enhancement with sub-dermal heating with FaceTite, submental fat reduction with Necktite and fractional ablative treatment with Fractora resurfacing.

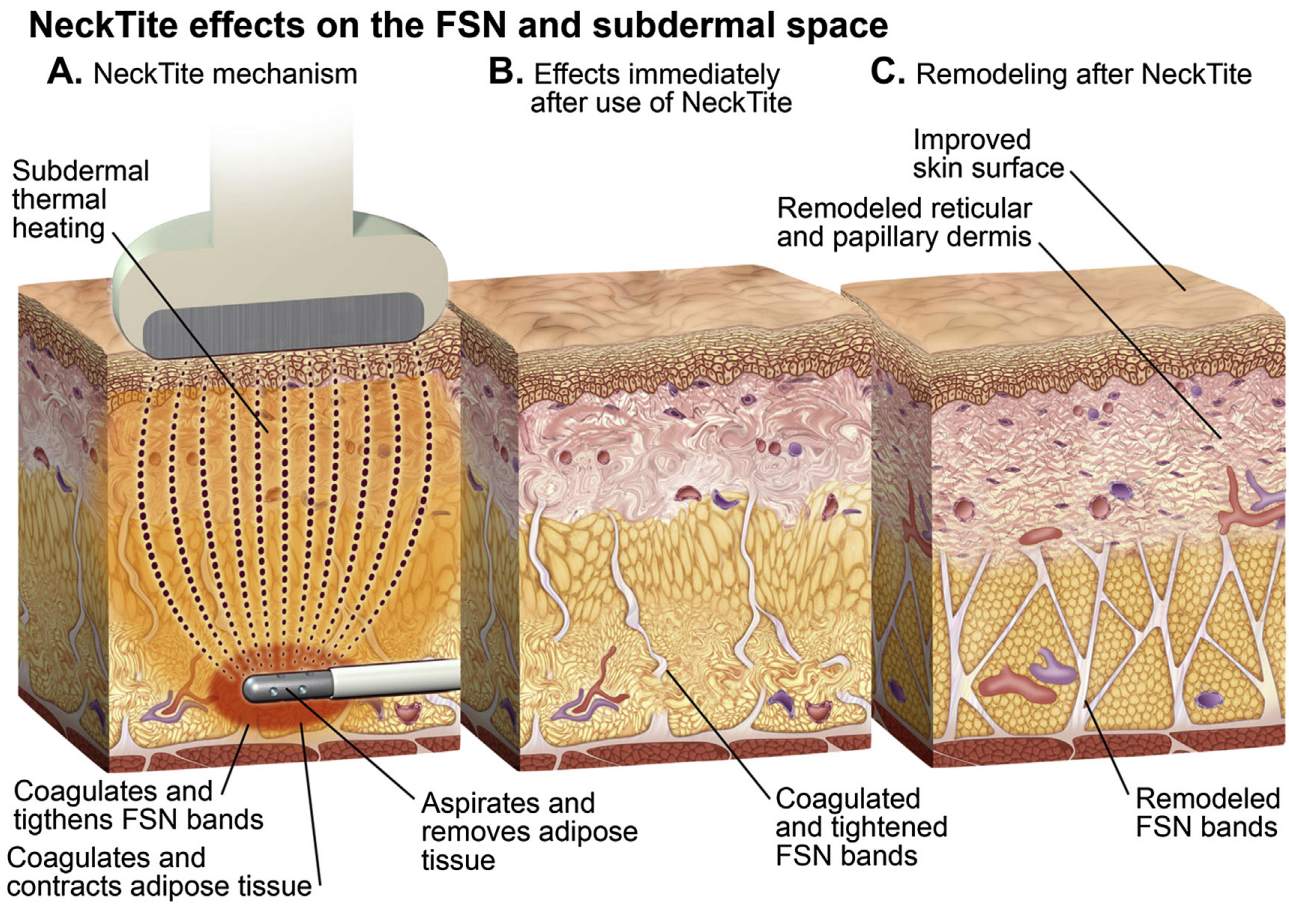

Fig. 16. Effect of NeckTite on subdermis.

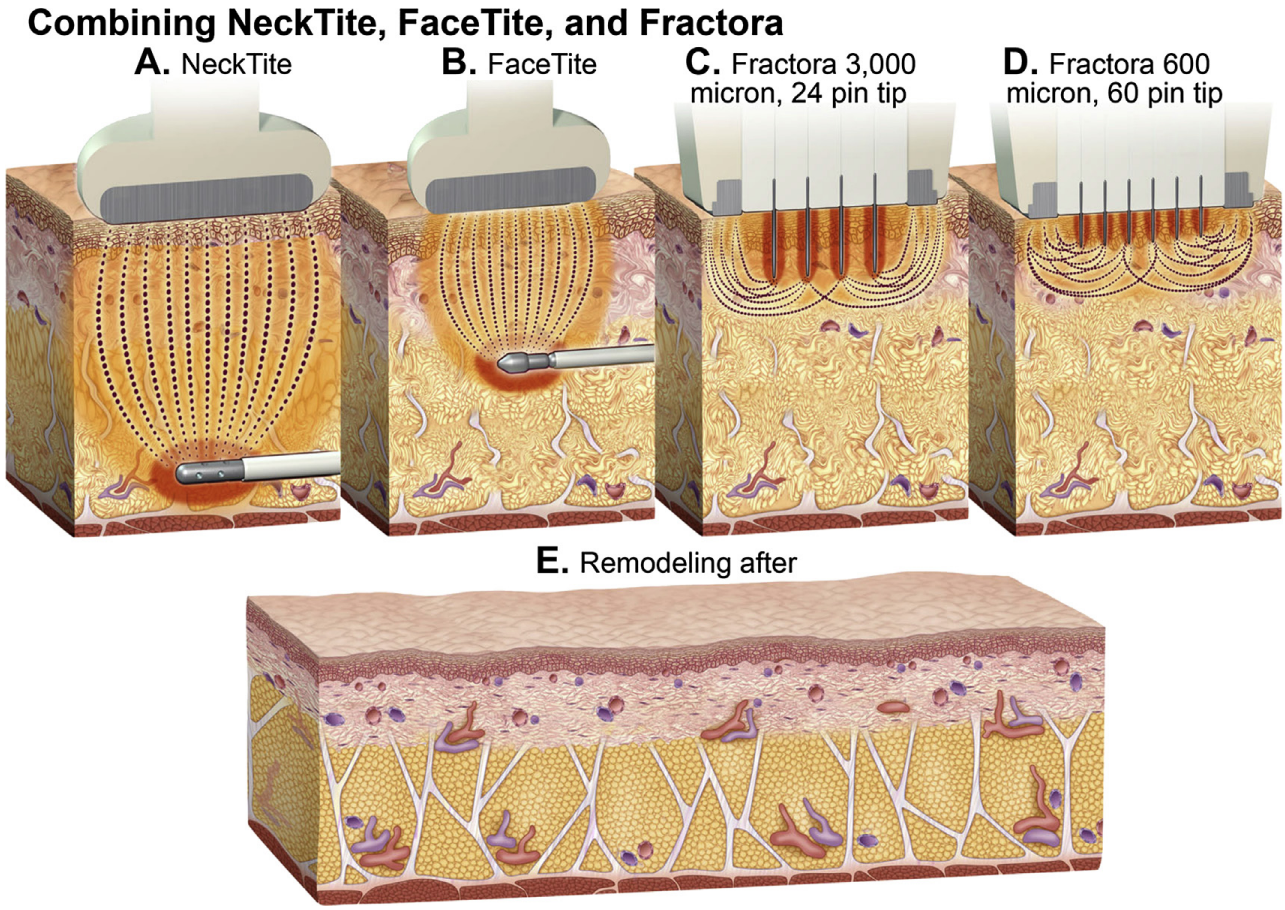

Fig. 17. The combination of internal RFAL applicators for the reduction of submental fat and FSN soft tissue contraction, using NeckTite (*A*), sub-dermal skin tightening using FaceTite (*B*), Deep (*C*) and superfical ablative fractional RF resurfacing and non-ablative tightening with Fractora.

the base of the ablation through the deeper papillary and reticular dermis to the negative-side electrodes (see **Fig. 8**). Unlike fractional CO2, erbium, fractional RF resurfacing with this Fractora device can induce both an ablative rejuvenation of cervical dyschromia, fine lines, and rhytides, as well as nonablative deeper dermal cervical tightening. Simultaneous combination therapy, subdermal laser, or RF and transepidermal laser or RF, will often optimize the cervical rejuvenative therapeutic effect. The Fractora or other fractional ablative laser devices can be combined with IPL, laser, and other chromophore light-based systems together on the same visit with the FaceTite and/or NeckTite subdermal RFAL or subdermal laser to result in a multilayer cervical combination therapy that can optimize overall soft tissue color, texture, and contraction control.

There have been peer-reviewed studies reviewing the deployment of direct intra-adipose lipolytic injections in the submental space. These injections deploy substances such as phosphatidylcholine and deoxycholate to chemically damage the adipocytes, improving contour.[71–73] Modest reductions of fat can occur using this technique, but, like SAL or UAL skin contraction, would be limited and color correction and texture improvement would necessitate the addition of light and energy-based systems.[73] There are newer adipose injection products being deployed for direct intra-adipose lipolysis that may hold some promise when used in combination with subdermal tightening techniques.

Platysma and cervical muscular layer

Deep to the subcutaneous adipose tissue is the platysma muscle. The platysma muscle is a thin straplike muscle that runs from the clavicle to the dermis of the mandible. It may or may not possess a medial decussation and, when taut, can create an enhanced and youthful cervicomental angle; but when lax, often creates visible and aging medial platysmal bands or cords and lateral platysmal bands. The anterior-posterior contraction of the platysmal muscles will also eventually lead to horizontal lines, or “necklace lines.”

Medial platysma bands

Medial platysma bands can be divided into dynamic hypertrophic medial platysma bands and flaccid, atrophic medial platysma bands. Dynamic hypertrophic bands are usually more common in

younger patients, and can compromise the cervicomental angle. Hypertrophic and dynamic medial platysma bands respond well to intramuscular injections of neuromodulators, such as botulinum toxin type A. This botulinum type A can include Botox, from Allergan (Irvine, CA), Dysport from Medicis/Valeant (Laval, Canada), and Xeomin from Merz (Frankfurt, Germany). Techniques for cervical injections include distraction and direct injection into the platysmal muscles, subcutaneous injections, or intradermal injections. The neuromodulator has a trophic capability to find its way to the presynaptic cleft of the motor axons in the platysmal muscle and provide a chemical denervation that prevents release of acetylcholine when one wants to activate the platysma bands. By chemically denervating the medial platysma bands, they will relax and in the dynamic hypertrophic patient, provide enhanced acuity of the cervicomental angle and reduced visibility of the aging appearance of the medial cords.[4,5] For the medial platysma bands, if the dynamic hypertrophic bands extend to the hyoid, doses of 15 units on either side can be deployed. If the bands extend below the hyoid to the level of the thyroid, or inferiorly to the sternal notch, another 15 to 30 units on either side of the platysma bands can be deployed. Care should be taken when injecting botulinum type A into platysma muscles that the injection is not performed too deeply or with copious amounts of neuromodulator, as cases of cervical dysphasia and swallowing difficulties have been reported, as well as difficulty lifting one's head due to sternocleidomastoid weakness.

Dynamic hypertrophic lateral platysma bands can also contribute to the aged appearance of the neck. The lateral platysma bands can act as a secondary depressors of the midface. Particularly when depressor angularis oris is blocked with botulinum toxin, lateral platysma hypertrophic patients will often overactivate the lateral platysma bands, creating a visually displeasing appearance to the neck, as well as causing a secondary depressed effect on the modiolus of the commissure and depressor effects on the midface. Direct Botulinum toxin A injection to the lateral platysma band, a procedure also called the "Nefertiti lift," has been advocated using15 units used on either side.[4,5]

Anterior-posterior cervico and platysma flexion also create necklace lines. These can cause an aged appearance to the neck and multiple-site, low-dose intradermal or subcutaneous injections of botulinum type A, approximately 2 units every 2 to 6 cm along the entire necklace line, can provide a softening or rejuvenation of this region.[4,5]

The skin of the neck is very thin and the use of soft tissue fillers in cervical rejuvenation is somewhat limited, but for patients who have significant fine rhytides and horizontal lines, very dilute subdermal injections of particulate biostimulants such as Sculptra (polygalactic acid) can result in stimulation and a neo-collagenesis, with thickening of the dermis.[74,75] These techniques need to be performed with a very dilute solution (10:1 dilution) or fibroplastic nodules can result. Deploying very dilute hyaluronic acid gels in the subdermal space, as well as PRP (protein-rich-plasma) and other stem cell treatments, have also reported to provide reasonable rejuvenation of the neck. The neurotoxin and subdermal injectable biostimulants can, of course, be combined with transepidermal IPL on the neck to correct color and the fractional ablative techniques, RF or laser, for textural enhancement as discussed earlier in the article for combination therapy in neck rejuvenation. This kind of creative "combination therapy" can deliver outstanding soft tissue rejuvenation of the neck (see **Fig. 17**).

Laxity treatment of oblique cervicomental angle in the lax neck

Patients who have muscular laxity of the medial and lateral platysma muscle and obliquity of the cervicomental angle can often achieve nice aesthetic improvements with thread or suture suspension.[76–81] Two forms of suture suspension have been described in the literature, both of which have shown to provide nice results in selected patients:

1. Giampapa lift or suture suspension technique
2. Lateral suspension techniques or thread lifts

In the *Giampapa-lift or suture suspension technique*,[79] a small submental incision with elevation of flaps, allows visualization of the hyoid. Two interlinked polypropylene 4-0 or 3-0 nylon sutures are then passed through the hyoid periosteum. Following undermining of the lateral neck, with or without liposuction, again, the needle-based end of the polypropylene loop is then grabbed on both sides and passed using a very long clamp from the hyoid in the central neck to the retroauricular, mastoid space. Both ends of the now interlinked polypropylene suture are tightened and sutured to the mastoid and this creates an elevation of the hyoid, contouring the cervical soft tissue and enhancing the cervicomental angle.[79] In the properly selected patient, with a reasonable amount of subcutaneous adipose tissue, this can provide a pleasing and minimally invasive improvement. Of course, this suture suspension technique can be combined with any of the aforementioned subdermal and subcutaneous

adipose-contouring techniques, subdermal-heating techniques, fractional ablative and light-based therapy, and neuromodulator techniques to enhance the results.

Lateral suspension techniques can be performed using various sutures that are either smooth or barbed or some type of resistance technology, such as cones, attached to the thread.[76–81] These lateral lifting techniques have generally been referred to as thread lifts and the most common techniques used in the neck incorporate fixation of the thread to the mastoid cervical fascia, although there were earlier suture-contouring technologies that did not incorporate solid fascial suture fixation.[78,79]

Simple polypropylene loops passed in the subdermal space and pulling the neck laterally and fixing the propylene to the cervical fascia can create modest improvements in the cervicomental angle. Barbed sutures or poly-l-galactic cones contained on a polypropylene backbone have been used and pass from lateral to medial to provide nice, significant early cervicomental contouring.[76,80,81] However, the long-term results of neck contouring using simple barbed or absorbable cone-based suture materials have generally resulted in a significant recurrence of cervicomental laxity, owing to extreme mobility of the neck and axial rotational movements. None of these lateral suture or device tension techniques deploy excision and the modest excess skin accumulates at the hair line and relaxes and remodels over time. Although short-term results can be favorable, there are very few reports of long-term cervical enhancements using these techniques, although further developments in the technology of suture and device suspension may improve the results from minimally invasive suspension cervicomental approaches.

Prominent digastric muscles

Occasionally, when large hypertrophic anterior bodies of the digastric are suspected of contributing to fullness of the immediate submental plane, in absence of significant fat, intramuscular botulinum toxin can reduce the fullness and improve the submental contour.[4,5]

Prominent submandibular glands

It is not uncommon for thin-necked patients to present with bulges in the submandibular space of the mandibular midbody. These bulges appear as displeasing shadows and are often a result of "low-hanging" submandibular glands.[3] The presence of prominent submandibular glands can be diagnosed through bimanual palpation (one finger on the floor of the mouth, one transcutaneous) and feeling a smooth, soft glandular structure that often measures 4 to 5 cm in length and 1 to 3 cm in width. When submandibular glands are somewhat ptotic and enlarged, they can create an aged, shadowy appearance to the neck.

Botox has been deployed for the management of sialorrhea, both clinically and experimentally with reduction of saliva and histologically smaller glands.[82–84] The author has deployed a minimally invasive technique for managing enlarged, aesthetically displeasing submandibular glands by deploying botulinum toxin with direct injection into the submandibular gland, with 15 to 30 units of botulinum A per side. This glandular injection is most safely done with a bimanual technique (one finger in the floor of the patient's mouth, pushing on the submandibular gland, and the contralateral hand guiding the needle gently into the gland) or more recently with ultrasound guidance. I prefer to do this in 3 injection sites into each gland, with 5 to 10 units in each injection. Thirty units in each gland usually results in 9 to 12 months of resolution of the gland's visibility. Similar to axillary hyperhidrosis, the botulinum toxin acts presumptively on the acinar secretory apparatus, shrinking it significantly and minimizing the appearance of the submandibular gland for a prolonged period. Obviously, care and attention must be taken not to inject botulinum toxin into any other structure in the floor of the mouth (or your finger!) or some dysphasia or disarticulation can occur. The submandibular glands are functionally insignificant in the healthy patient, as the sublingual glands secrete most of the necessary salivary volume and prevent any xerostomia. However, in patients who have had oral carcinoma with oral radiation, the submandibular glands are best not injected, as xerostomia can result.

The aging neck remains one of the greatest challenges for the aesthetic physician. Minimally invasive, nonexcisional techniques to rejuvenate the midface and brow have delivered tremendous success for noninvasive head and neck surgeons over the past 5 to 10 years. Because of its structure, location, and, often, sun exposure, the cervical submental region has presented more challenges to the aesthetic physician in achieving consistent nonexcisional rejuvenation. Over the past few years, with the evolution of subdermal heating techniques and transepidermal fractional ablative techniques, chromophore-based and light-based systems, alone on in combination with subdermal stimulation and suspension techniques, the aesthetic physician now has many weapons and tools to better address the noninvasive and minimally invasive, nonexcisional treatments of the aging neck.

REFERENCES

1. US Census Bureau. Selected characteristics of baby boomers 42 to 60 years old in 2006. Washington: US Census Bureau; 2006.

2. Moretti, Michael. Skin tightening; softening demand in a weak economy. Aliso Viejo, CA: Medical Insight Inc; 2008.

3. Feldman J. Neck lift. St Louis (MI): Quality Medical Publishing Inc; 2006.

4. Carruthers A, Carruthers J. Cosmetic uses of botulinum exotoxin. Adv Dermatol 1997;12:325–47 Vancouver, Canada: Mosby-Year Book Inc.

5. Carruthers J, Carruthers A. The adjunctive usage of botulinum toxin. Dermatol Surg 1998;24:1244–7.

6. Schwartz RJ, Burns J, Rohrich RE, et al. Long term assessment of CO2 facial laser resurfacing: aesthetic results and complications. Plast Reconstr Surg 1999;103(2):593–601.

7. Bernstein LJ, Kauvar AN, Grossman MC, et al. The short and long-term side effects of carbon dioxide laser resurfacing.Dermatol Surg 1997;23(7):519–25.

8. Olsen EA, Katz HI, Levine N, et al. Tretinoin emollient cream for photodamaged skin: results of 48- week, multicenter, double-blind studies. J Am Acad Dermatol 1997;37:217–26.

9. Kang S, Leyden JJ, Lowe NJ, et al. Tazarotene cream for the treatment of facial photodamage. A multicenter, investigator-masked, randomized, vehicle-controlled, parallel comparison of 0.01%, 0.025%, 0.05% and 0.01% taxarotene creams with 0.05% tretinoin emollient cream applied once daily for 24 weeks. Arch Dermatol 2001;137:1597–604.

10. Anderson RR, Parish JA. Selective photothermolysis: a precise microsurgery by selective absorption of pulsed radiation. Science 1983;220(4596):524–7.

11. Sadick NS, Alexiades-Armenakas M, Bitter PH, et al. Enhanced full face skin rejuvenation using synchronous intense pulsed optical and conducted bipolar radiofrequency energy (ELOS): introducing selective radiophotothermolysis. J Drugs Dermatol 2005;4(2):181–6.

12. Zelickson BD, Kilmer SL, Bernstein E, et al. Pulsed dye laser for sun damaged skin. Lasers Surg Med 1999;25:229–36.

13. Weiss RA, Goldman MP, Weiss MA. Treatment of poikiloderma of civatte with an intense pulsed light source. Dermatol Surg 2000;26:213–8.

14. Bitter PH. Non-invasive rejuvenation of photodamaged skin using serial, full-face intense pulsed light treatments. Dermatol Surg 2000;26:9.

15. Bitter PH, Goldman MP. Non-ablative skin rejuvenation using intense pulsed light. Lasers Surg Med 2000;28(Suppl):12–6.

16. NegisThi K, Tezuka Y, Kushikata N, et al. Photorejuvenation for Asian skin by intense pulsed light. Dermatol Surg 2001;27(7):627–32.

17. Manstein D, Herron GS, Sink RK, et al. Fractional photothermolysis: a new concept for cutaneous remodeling using microscopic patterns of thermal injury. Lasers Surg Med 2006;34(5):426–38.

18. Geronemus RG. Fractional photothermolysis: current and future applications. Lasers Surg Med 2006;38(3):169–76. 19. Bass LS. Rejuvenation of the aging face using fraxel laser treatment. Aesthet Surg J 2005;25(3): 307–9.

20. Daniel D, Bernstein LJ, Geronemus RG, et al. Successful treatment of acneiform scarring with CO2 ablative factional resurfacing. Lasers Surg Med 2008;40(6):381–6.

21. Chapas AM, Brightman L, Sukai S, et al. Successful treatment of acneiform scarring with CO2 fractional resurfacing. Lasers Surg Med 2008;40(6): 382–6.

22. Gotkin RH, Sarnoff DS, Cannarozzo G, et al. Ablative skin resurfacing with a novel microablative CO2. J Drugs Dermatol 2009;8(2):138–44.

23. Rahman Z, Tanner H, Tournas J, et al. Ablative fractional resurfacing for the treatment of photodamage and aging. Lasers Surg Med 2007; 39(s19):15.

24. Hruza G, Taub AF, Collier LS, et al. Skin rejuvenation and wrinkle reduction using a fractional radiofrequency system. J Drugs Dermatol 2009;8(3): 259–65.

25. Mulholland RS, Ahn DH, Kreindel M, et al. Fractional radio-frequency resurfacing in Asian and Caucasian skin: a novel method for deep radiofrequency fractional skin resurfacing. J Chem Dermatol Sci Appl 2012;2:144–50.

26. Sadick NS. Update on non-ablative light therapy for rejuvenation: a review. Lasers Surg Med 2003; 32:120–8.

27. Hardaway CA, Ross EV. Nonablative laser skin remodeling.Dermatol Clin 2002;20:97–111.

28. Fitzpatrick RE, Geronemus RG, Goldberg DJ, et al. Multicenter study of noninvasive radiofrequency for periorbital rejuvenation. Lasers Surg Med 2003;33: 232–42, 14.

29. Dover JS, Zelickson BD. Results of a survey of 5,700 patient monopolar radiofrequency facial skin tightening treatments: assessment of a lowenergy multiple-pass technique leading to a clinical end point algorithm. Dermatol Surg 2007;33: 900–7.

30. Sadick NS, Trelles MA. Nonablative wrinkle treatment of the face and neck using a combined diode laser and radiofrequency technology. Dermatol Surg 2005;31:1695–9.

31. Sadick NS. Combination radiofrequency and light energies: electro-optical synergy technology in esthetic medicine. Dermatol Surg 2005;31: 1211–7.

32. Sadick HS, Sorhaindo L. The radiofrequency frontier: a review of radiofrequency and combined radio-frequency pulsed-light technology in aesthetic medicine. Facial Plast Surg 2005;21: 131–8.

33. Friedman DJ, Gilead LT. The use of a hybrid radiofrequency device for the treatment of rhytides and lax skin. Dermatol Surg 2007;33:543–51.
34. Kist D, Burns AJ, Sanner R, et al. Ultrastructural evaluation of multiple pass low energy versus single pass high energy radiofrequency treatment. Lasers Surg Med 2006;38:150–4.

35. Mulholland RS. Radiofrequency energy for noninvasive and minimally invasive skin tightening. Clin Plast Surg 2011;38(3):437–48.

36. Emilia del Pino M, Rosado RH, Azuela A, et al. Effect of controlled volumetric tissue heating with radiofrequency on cellulite and the subcutaneous tissue of the buttock and thighs. J Drugs Dermatol 2006;5(8):714–22.

37. Mlosek RK, Wozniak W, Malinowska S, et al. The effectiveness of anticellulite treatment using tripolar radiofrequency monitored by classic and high frequency ultrasound. J Eur Acad Dermatol Venereol 2012;26(6):696–703.

38. Kaplan H, Gat A. Clinical and histopathological results following tripolar radiofrequency skin treatments. J Cosmet Laser Ther 2009;11(2):78–84.

39. Harth Y, Lischinsky D. A novel method of real-time skin impedance measurements during radiofrequency skin tightening treatments. J Cosmet Dermatol 2011;10(1):24–9.

40. Lee YB, Eun YS, Lee JH, et al. Effects of multi-polar radiofrequency and pulsed electromagnetic field treatment in Koreans: case series and survey study. J Dermatolog Treat 2012. http://dx.doi.org/10.3109/09546634.2012.714454.

41. Taub AF, Tucker RD, Palange A. Facial tightening with an advanced 4-MHz monopolar radiofrequency device. J Drugs Dermatol 2012;11(11): 1288–94.

42. Stampar M. The pelleve procedure: an effective method of facial wrinkle reduction and skin tightening. Facial Plast Surg Clin North Am 2011; 19(2):335–45.

43. Mulholland RS. Skin tightening in Asian patients using a dynamically controlled and thermally modulated radiofrequency energy device with ACE technology. Presented IMCAS Asia. Hong Kong, October 4–6, 2012.

44. Mulholland RS. Skin tightening in skin type 1-4 patients using a thermally modulated, feedback controlled, non-ablative radiofrequency device. Presented at IMCAS. Paris, Jan 31–Feb 3, 2013.

45. Suh DH, Oh YJ, Lee SJ, et al. An intense-focused ultrasound tightening for the treatment of infraorbital laxity. J Cosmet Laser Ther 2012; 14(6):290–5.

46. Alam M, White LE, Martin N, et al. Ultrasound tightening of facial and neck skin; a rater-blinded prospective cohort study. J Am Acad Dermatol 2010; 62(2):262–9.

47. Illouz YG. Body contouring by lipolysis: a 5-year experience with over 3,000 cases. Plast Reconstr Surg 1983;72:591–7.

48. Gasperoni C, Salgarello M, Emiliozzi P, et al. Subdermal liposuction. Aesthetic Plast Surg 1990;14: 137–42.

49. Goddio AS. Skin retraction following suction lipectomy by treatment site: a study of 500 procedures in 458 selected subjects. Plast Reconstr Surg 1991;87:66–75.

50. Matarrasso A. Superficial suction lipectomy: something old, something new, something borrowed. Ann Plast Surg 1995;24:268–72.

51. Toledo LS. Syringe liposculpturing. Aesthetic Plast Surg 1992;16:287–98.

52. DiBernado BE. Randomized, blinded, split abdomen study evaluating skin shrinkage and skin tightening in laser-assisted liposuction versus liposuction control. Aesthet Surg J 2010;30(4): 593–602.

53. Sasaki GH. Quantification of human abdominal tissue tightening and contraction after component treatments with 1064 nm/1320 nm laser-assisted lipolysis: clinical implications. Aesthet Surg J 2010;30:239–45.

54. Rohrich RJ, Beran SJ, Kenkel JM, et al. Extending the role of liposuction in body contouring with ultrasound-assisted liposuction. Plast Reconstr Surg 1998;101:1090–102.

55. Zocchi ML. Ultrasonic liposculpturing. Aesthetic Plast Surg 1992;16:287–98.

56. Zocchi ML. Ultrasonic assisted lipoplasty: technical refinements and clinical evaluations. Clin Plast Surg 1996;23:575–98.

57. Goldman A. Submental Nd:YAG laser-assisted liposuction. Lasers Surg Med 2006;38:181–4.

58. Prado A, Andreades P, Danilla S, et al. A prospective, randomized, double-blind, controlled clinical trial comparing laser-assisted lipoplasty with suction-assisted lipoplasty. Plast Reconstr Surg 2006;118:1032–45.

59. Paul M, Mulholland RS. A new approach for adipose tissue treatment and body contouring using radiofrequency-assisted liposuction. Aesthetic Plast Surg 2009;33(5):687–94. http://dx.doi.org/10.1007/s00266-009-9342-z.

60. Blugerman G, Schavelzon D, Paul M. A safety and feasibility study of a novel radiofrequency-assisted liposuction technique. Plast Reconstr Surg 2010; 125:998–1006.

61. Mulholland RS. An in-depth examination of radiofrequency assisted liposuction (RFAL). J of Cosmetic Surg and Medicine 2009;4:14–8.

62. Paul M, Blugerman G, Kreindel M, et al. Threedimensional radiofrequency tissue tightening: a proposed mechanism and applications for body contouring. Aesthetic Plast Surg 2010;35(1):87–95 published with open access.

63. Paul MD. Radiofrequency assisted liposuction comes of age: an emerging technology offers an exciting new vista in non-excisional body contouring. Plastic Surgery Practice 2009;2:18–9.

64. Duncan DI. Improving outcomes in upper arm liposuction: adding radiofrequency-assisted liposuction to induce skin contraction. Aesthet Surg J 2012;32(1):84–95.

65. Theodorou SJ, Paresi RJ, Chia CT. Radiofrequency-assisted liposuction device for body contouring: 97 patients under local anesthesia. Aesthetic Plast Surg 2012;36(4):767–79.

66. Blugerman G, Schalvezon D, Mulholland RS, et al. Gynecomastia treatment using radiofrequencyassisted liposuction (RFAL). Eur J Plast Surg 2012. http://dx.doi.org/10.1007/s00238-012-0772-5. Published Online.

67. Divaris M, Boisnic S, Branchet MC, et al. A clinical and histological study of radiofrequency-assisted liposuction (RFAL) mediated skin tightening and cellulite improvement. J Chem Dermatol Sci Appl 2011;1:36–42.

68. Duncan DI. Improving outcomes in abdominal liposuction; comparing skin contraction with radiofrequency assisted lipocontouring (RFAL) plus SAL to SAL alone. Presented IMCAS. Paris, Jan 6–9, 2011.

69. Ahn DH, Mulholland RS, Duncan DI, et al. Nonexcisional face and neck tightening using a novel subdermal radiofrequency thermo-coagulative device. J Chem Dermatol Sci Appl 2011;1:141–6.

70. Hurwitz D, Smith D. Treatment of overweight patients by radiofrequency-assisted liposuction (RFAL) for aesthetic reshaping and skin tightening. Aesthetic Plast Surg 2012;36(1):62–71. http://dx.doi.org/10. 1007/s00266-011-9783-z Published online.

71. Duncan DI. The evolution of mesotherapy. Presented at the ASPS Breast and Body Contouring Symposium. Santa Fe (NM), Oct 4–6, 2012.

72. Duncan DI. Injection lipolysis update. Presented at IMCA Asia. Hong Kong, Oct 4–6, 2012.

73. Rotunda AM. Mesotherapy and phosphatidylcholine injections: historical clarification and review. Dermatol Surg 2006;32:465–80.

74. Lam S, Azizzadeh B, Graivier M. Injectable poly-llactic acid (sculptra): technical considerations in soft-tissue contouring. Plast Reconstr Surg 2006; 118:55–66s.

75. Beer KR, Rendon MI. Use of sculptra in esthetic rejuvenation. Semin Cutan Med Surg 2006;25:127–31.

76. Mulholland RS, Paul MD. Lifting and wound closure withbarbedsutures. ClinPlast Surg 2011;38:521–35.

77. Ruff G. Techniques and uses for absorbable barbed sutures. Aesthet Surg J 2006;26:620–8.

78. Lycka B, Bazan C, Poletti E, et al. The emerging technique of the antiptosis subdermal thread. Dermatol Surg 2004;30:241–7.

79. Giampapa VC, DiBernado BE. Neck re-contouring with suture suspension and liposuction. Aesthetic Plast Surg 1995;19:217–24.

80. Gamboa GM, Vasconez LO. Suture suspension technique for the midface and neck rejuvenation. Ann Plast Surg 2009;62:478–81.

81. Mulholland RS. Advances and updates in barbedsuture composite face and necklifts. Presented at IMCAS. Paris, Jan 9–12, 2008.

82. Coskun BU, Savk H, Cicek ED, et al. Histopathological and radiological investigations of the influence of botulinum toxin on the submandibular gland of the rat. Eur Arch Otorhinolaryngol 2007; 264(7):783–7.

83. Breheret R, Bizon A, Jeufroy C, et al. Ultrasoundguided botulinum toxin injections for the treatment of drooling. Eur Ann Otorhinolaryngol Head Neck Dis 2011;128(5):224–9.

84. Shetty S, Dawes P, Ruske D, et al. Botulinum toxin type-A (Botox-A) injections for treatment of sialorrhea in adults: a New Zealand study. N Z J med J 2006;119(1240):U2129.