Chapter

Contractile Effects of Radiofrequency Energized Helium Plasma on the Fibrous Septal Network

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Abstract

Body contouring with liposuction has evolved significantly from the early approach of simply debulking excess fatty tissue, to affecting the mechanical properties of different tissue types and layers. Operative paradigms have been expanded to apply energy-based technologies intraoperatively to provide more uniform aspiration, selective fatty tissue emulsification in soft and fibrous body areas, minimize trauma to nerves and vessels, expose the fibrous septal network, reduce operator fatigue and help deliver smooth shapes with less discomfort and bruising. Advanced refinements with the delivery of monopolar and bipolar radiofrequency energy for soft tissue heating have been shown to reduce the residual soft tissue laxity that often follows voluminous fat removal. The Renuvion® (Apyx™ Medical, Clearwater, FL) radiofrequency powered helium plasma technology introduces an emerging concept in which the delivery of subdermal thermal energy preferentially coagulates the fascia and fibrous septal network through a conductive helium plasma stream seeking the path of least resistance, which in turn results in collagen contraction and tissue shrinkage that permits re-draping of the skin and enhanced definition. The physics and mechanics of Renuvion® subdermal soft tissue coagulation will be presented, along with clinical applications that have provided the authors more contouring finesse and has augmented liposuction outcomes.

Keywords: Liposuction, Radiofrequency, Collagen contraction, Skin tightening, Body contouring, Plasma

1. Introduction

Liposuction is a well-established surgical procedure that is continuously evolving with refinements in surgical technique, safety, patient assessment, and care. The introduction of tumescent solution decades ago markedly reduced complications, such as blood loss, associated with dry liposuction. While reducing the overall volume of a given region is accomplished with traditional manual liposuction, the resultant soft tissue deflation has historically been the only means of contouring with minimum reduction in the actual surface area. Areas that were pendulous were still best treated with dermatolipectomy. Furthermore, concerns of iatrogenic post aspiration skin laxity frequently led surgeons to under-aspiration, while over resection driven by a desire for improved shaping, equally resulted in overall contour problems. Skin contraction in surface area one year post traditional manual liposuction was shown to be around 10% [1]. Over the past few decades, technologies have sought to further enhance liposuction treatment speed with economy of motion and reduced operator fatigue, while increasing fat emulsion and enhancing soft tissue contraction beyond the normal deflation that accompanies removal of internal turgor by fat removal and cannula stimulation. The resulting nonthermal inflammation, blood vessel ingrowth, and fibroblast production of collagen offers however, an uncontrollable and unpredictable skin shrinkage. The use of mechanical and ultrasonic powered disruption of fat has also been used to better treat fibrous areas. Some examples that deliver smoother, more uniform fat removal include power assisted liposuction with oscillating cannulas (MicroAire Surgical Instruments, Charlottesville, VA), light amplification by stimulated emission of radiation (LASER) fibers and vibration amplification of sound energy and resonance, VASER® (Solta Medical, Bothwell, WA). As an added benefit, enhanced adipose cell viability for fat grafting has resulted with the use of VASER® and Water jet assisted liposuction, a technique in which a dual-purpose cannula, and pulsating, fanning jets of tumescent solution are implemented along with simultaneous suctioning of fatty tissue. However, downsides to each of the technologies have arisen. The applications of mechanical powered disruption have been limited by the potential for damage to other tissues, including nerves, blood vessels and skin, while adding operative time and not offering skin or soft tissue tightening. Similarly, early ultrasound assisted technologies were also time consuming and plagued by complications of seromas, burns and undesirable contours. The still popular ultrasonic VASER® device, LASER assist and radiofrequency (RF) assisted liposuction have yielded many advantages and superior outcomes as outlined in later sections.

As more refinements in non-excisional body contouring emerge, patient expectations of enhanced definition and sleeker contours are driving research and innovations proportionately. Contemporary efforts now focus not solely upon removal of excess fat, but on composite tightening of skin and its underlying soft tissue support system. The Renuvion® (Apyx™ Medical) technology offers the latest advancement in composite liposuction results by thermally altering multiple different tissue types with a radiofrequency energized helium plasma stream. The combination of either LASER or VASER® lipolysis with Renuvion® subdermal coagulation creates superior soft tissue contraction and reductions in volume and surface area.

2. Thermal collagen contraction basics

Soft tissue contouring depends upon deflation and contraction. As we age, collagen stretches, fragments and attenuates whether in the dermis, fibrous septae, connective tissue around fat lobules, retaining ligaments, SMAS or other fascia. Soft tissue laxity is a result of decreasing underlying support from atrophy of the dermis, fibrocollagenous and vascular matrices, adipose layers, muscle and bony mass. In particular, skin laxity is evidenced by decreased type 1 collagen formation, increased degradation of the extracellular matrix and overall loss of dermal elastic recoil. Attempts at modifying the deep dermal tissue level with superficial liposuction have been met with mixed results of skin shrinkage, and not uncommonly are associated with adverse events such as pigmentation changes, chronic induration, seroma, surface irregularities, and full thickness skin necrosis. Consequently, attempts to restore collagen fibers safely and predictably has become the focus of liposuction research. Collagen fibers rapidly contract approximately one third the resting length, in response to heat to an extent that is dependent upon the temperature and duration of the temperature [2]. The temperature at which collagen denaturation occurs is 66.8° C, depending upon the tissue type [3, 4]. Thermally induced soft tissue contraction that follows is a product of the wound healing response that includes neo-collagenesis, restructuring of collagen fibers and tissue remodeling. These same changes reinforce the use of tumescent solution during liposuction to reduce the energy conductance of tissue, to reduce tissue impedance and distribute delivered heat. It has been observed that the behavior of collagen fibers changes with the aging process, making heat assisted lipo-contouring more challenging in older patients. It is believed that in older skin, collagen is less responsive to thermal energy because irreducible multivalent cross links replace the heat labile collagen intramolecular bonds found in younger skin [5]. Effectively altering the thermomechanical behavior of tissue constituents embedded in a plexus of collagen and elastin is then the primary mechanism of energy assisted lipo-contouring in patients of all ages.

3. Laser lipolysis effects

LASER assisted lipolysis offers efficacious fat extraction, better hemostasis and finessed sculpting with thermal heating of fibrous septae in areas difficult to obtain tissue retraction. Multiple wavelengths, such as the 1064 nm and 1320 nm., have been shown to effectively coagulate small blood vessels, rupture adipocytes, coagulate adipose collagen strands and help to reorganize the reticular dermis. Light energy is delivered to subdermal tissue through a small fiber threaded through a 1 mm microcannula with the tip extending a few mm beyond the microcannula end. Data established by the works of Havenith, et al. [6] and Salzman, et al. [7] offer precise calculations to determine the laser energy required to cause collagen fiber contraction without causing a burn. Havenith et al., showed that it takes about 2.51 joules of laser energy to raise the temperature of 1 ml of fat 1° Celsius. Since the density of fat is 0.9 grams/cc, the resultant requirement is 2.3 joules per cc. As damage begins to occur at 43° C, the goal should be to raise the temperature no more than 5° Celsius. The volume of fat to be liquified is estimated roughly by measurements of the length X width X thickness of the treatment area. Hence, the amount of laser energy that should be delivered is the product of volume X 2.3 X 5. Following laser application, higher mean skin stiffness and tightening has been demonstrated at 3 months when compared to traditional manual liposuction alone [8]. Notwithstanding, studies that have shown modest decreases in skin surface area reduction, added operative time, sequalae such as local skin burns, and limited longevity have tempered the recent popularity of this modality.

4. Benefits of VASER®

Like the LASER, the use of VASER® adds operative time but reduces operator fatigue. Yet, unlike the LASER, VASER® offered notable advances that allow for selective tissue emulsification, lower lipoaspirate hematocrit levels, and preservation of adipocyte derived stem cells for fat grafting [9]. VASER® probes designed with rings and grooves on the tip deliver vibratory energy from the end surface and sides, permitting mechanical penetration of fibrous tissue and micro-cavitation of adipose cell membranes, whilst preserving the musculocutaneous connective tissue matrix, nerves and vessels. Energy emanates from the probe tip and rings continuously or in pulsed mode, a feature that provides additional safety with high energy probe vibration for shorter time bursts. Following tumescent solution infusion, probes are cross tunneled through multiple skin protector ports, smoothly and continuously until there is a loss of resistance. As VASER® proceeds, the resistance in the tissue is palpably diminished as adipose cells liquify. The acoustic streaming by VASER® prepares fat for suctioning, but when used alone at low energy levels, there is minimal thermal energy generation. Some thermal skin tightening has been reported at 90% energy levels when delivered continuously for 2 minutes [10]. Overall, there has been inconsistent coupling of clinically observable skin contraction with subsequent fat removal when using VASER® alone. Notwithstanding, the addition of VASER® to the operative sequence helps to expose the numerous fibrous septae amidst densely packed fat in the supra-Scarpal space and the widely spaced fibrous septae that run amidst loosely packed fat lobules in the supra-Scarpal space. The author purports that the exposure of the fibrous septal network for subsequent thermal energy targeting by Renuvion® is key to optimizing the heating of the low impedance collagen fibers for increased soft tissue contraction overall.

5. Advantages of radiofrequency energy

Radiofrequency (RF) is a form of electromagnetic energy that can be converted to thermal energy. It does not target a particular chromophore. The early RF devices created bulk heating. When thermal energy emanated from the device tip, adjacent tissue heating occurred, leading to gradual warming and uneven heating, which became problematic and unpredictable in large treatment surface areas. With gradients of heat, areas of fibrosis can result from excessive heat delivery, which introduces further potential issues in regions of pre-existing compromised blood flow, little adiposity, and thin skin. Multiple RF devices, monopolar (Thermi) and bipolar (Invasix, InMode) with internal and external temperature probes and indwelling liposuction aspiration cannulas, were introduced in the past 12 years. With encouraging results, and safety features that monitor treatment depth and skin temperatures to help avoid visible burns, or the safety to offer rapid cooling to avoid burns altogether, the use of RF devices for enhancing body contouring have gained traction [11, 12]. In addition, other aesthetic applications have emerged to shrink lax soft tissue, as for SMAS tightening during rhytidectomy and popcorn capsulorraphy in breast implant repositioning surgery, and ongoing efforts to manage abdominal wall fascial laxity [13]. As described in the next section, a novel RF based device, Renuvion® (Apyx™ Medical), uses an energized stream of helium gas, known as a plasma, for the same purpose of precise soft tissue subdermal coagulation.

Like the lasers, the thermal energy delivered by an RF device can be calculated and provide treatment guidelines. The amount of energy is the product of the square of current multiplied by tissue impedance multiplied by the time of application [5, 14]. As adipose tissue has high tissue resistance or impedance to electromagnetic current, it has proven to be a good target for RF technologies to diminish iatrogenic tissue laxity and enhance liposuction results. Recalling that the total ability to re-drape the skin is related to the contractile nature of the dermis, as reflected by dermal thickness, the amount of FSN and fat to be aspirated, the delivery of RF energy to multiple tissue planes has proven advantageous. Treating the immediate subdermal layer leads to neo-collagenesis and subdermal remodeling, while treating above and below Scarpa's fascia maximally augments fat liquification, coagulates blood vessels, and creates an active fibroblastic reaction that replaces liquified fat [15, 16], neo-angiogenesis, and a compact, reorganized layer of collagen and elastin over 4–6 months [17]. The delivery of immediate heating between 60 and 80°C causes collagen fibrils to contract to one third their length and alters the microenvironment of the extracellular matrix toward favorable remodeling and healing. This begs the question as to whether repeated thermal effects on dermal ground substance can occur, and if there is a role for retreatment in secondary surgery to gain additional contraction. Notwithstanding, significant longevity of skin contraction has been demonstrated in clinical bipolar RF assisted liposuction studies that have shown 25% soft tissue area contraction at 6 months and 35–40% at one year [18]. As radiofrequency offers immediate and long- lasting thermal contraction of the FSN and inflammatory dermal heating, it has come to the forefront of contemporary energy assisted liposuction technologies, like Renuvion®.

6. Plasma background

Plasma is created when a gas is energized to a level that accelerates and frees electrons, resulting in a mixture of neutral atoms, charged ions and molecules. Plasmas occur in nature, within stars and the polar aurora. Early research on plasmas arose from controlled laboratory conditions and gave rise to applications within Medicine. Today, medical plasmas are in use for a spectrum of applications, including wound debridement, tissue regeneration, reducing cancerous cell proliferation and inducing selective apoptosis of neoplastic cells [19]. Medical plasmas are used in minimally invasive surgery in the fields of Gynecology, Urology, Otolaryngology and Gastrointestinal endoscopy. A well-known example is the Argon plasma technology used for soft tissue coagulation to reduce bleeding and tissue ischemia [20]. As discussed below, the use of a stream of ionized inert gas to deliver radiofrequency energy provides an advantageous alternative energy source for skin and soft tissue contraction.

7. Physics and mechanics of Renuvion®

Renuvion® is a helium-based plasma and radiofrequency technology that has been cleared by the Food and Drug Administration for cutting, coagulation and ablation of soft tissue. It creates a direct discharge, non-equilibrium, low temperature plasma beam at atmospheric pressure as helium gas is passed over a sharp, conductive point held at high voltage and high frequency. The system consists of a RF generator, supply of helium gas and an electrode within the tip of a handpiece [21]. The generator operates at a maximum of 4.0 kV, 40 Watts and 490 kHz frequency [22]. Independently tunable power levels, gas flow rates and pulsing of energy delivered provides a high level of precision. Unlike monopolar and bipolar instruments, the Renuvion® handpiece does not conduct heat after its application.

Renuvion® provides rapid heating of tissue in 360° with minimal depth of treatment. Heat is generated by two methods. The first is the ionization and rapid neutralization of helium atoms as the gas passes over the RF energized electrode. Second, a portion of RF energy used to energize the electrode is carried to the tissue by the plasma stream, whereby the tissue's resistance generates heat [23]. The electrosurgical generator maintains a consistent power output over a range of impedances [10]. In contrast, monopolar and bipolar devices have limited power output in tissues with greater impedance [10]. The mechanical movement of the handpiece and hence, the direction of plasma flow subcutaneously, is tracked by the light spray generated by the plasma streams. In Renuvion®, the colorless, monatomic, inert helium gas stream also delivers kinetic energy to clear the target tissue of fluid or debris [24].

At clinically equivalent settings, Renuvion® offered more control of tissue response with lower lateral and depth of thermal spread compared to monopolar, Argon, CO2 laser [25]. In a porcine model utilizing kidney, muscle, ovarian and uterine tissue blocks, the depth and spread of coagulation were found to be a function of the current density, gas flow rate, duration of application and distance of the probe tip to the target tissue [24]. Increasing the power increased the heat energy delivered to the tissue [24]. Histologic analysis demonstrated 2 mm depth of thermal spread following 5 sec of 100% power and 5 L/min Helium gas flow [24]. The same study demonstrated that prolonged exposure up to 30 seconds did not increase the depth of thermal effect over 3 mm, just the length and width of thermal spread, in all tissue types studied [24]. The depth of collagen denaturation was seen histologically to be 0.180–0.247 mm at both 50% and 100% power. Conductive heat transfer to surrounding tissues offers less heat transfer to the epidermis, thereby eliminating the need for external temperature monitoring.

The inherent resistance (impedance) to the flow of RF current through tissue increases as tissue is treated and desiccates. The RF current will preferentially flow through the path of least resistance characterized by the lowest tissue impedance. As such, the plasma beam alternates between treating different tissues surrounding the device. Continuous movement of the handpiece further introduces new, lower impedance tissue to the tip and delivers uniform energy to a large area. This lowers the need for the user to constantly redirect the handpiece. The RF energized plasma stream preferentially seeks tissue with the lowest impedance, like the fibro-septal network, to receive the majority of energy and undergo coagulation and contraction [26]. The low current of the Renuvion® device further disperses and prevents tissues from being over treated when multiple treatment passes are done. The increase in tissue impedance from coagulation preferentially diverts Renuvion® energy towards adjacent untreated tissue with subsequent passes. Subsequent live swine studies outlined the impact of device settings on the internal and external tissue temperatures with the use of a Forward-Looking Infrared Camera [26]. It was demonstrated that 6 passes of 60–80% power, at 1–4 lpm gas flow, and a handpiece speed of 1 cm/sec, raised internal temperatures to above 85° Celsius for a duration of 0.08 seconds, while external skin temperatures stayed within a safe range of 3.6° of baseline [26]. The internal tissue heating cycle lasted an average of 0.24 seconds from the time in which the handpiece tip approached to raise the target tissue temperatures, passed directly over and then moved past to lead to a rapid return to baseline temperatures. Maximum collagen contraction occurred within 0.044 seconds [2, 26]. The rapid rise to 85° Celsius is important as 10 times more time is needed to contract collagen for every 5° drop in temperature [17]. This makes Renuvion® technology very efficient compared to many other technologies. In contrast, bulk heating devices (Thermi, InMode) uses a radial pattern of heat directed primarily to the dermis that is maintained at optimal temperatures for comparatively prolonged time (>120 sec) for maximum contraction to occur, thereby increasing treatment times and requiring constant monitoring of epidermal temperatures [1].

Within the operative sequence, Renuvion® is utilized after tumescence and liposuction. It is important to note that the use of tumescent solution enlarges the space for handpieces to travel and provides a means for RF conduction, as adipose tissue is less conductive. Each access port is the apex and offers a fan shaped pattern for the handpiece strokes. The visible pattern and intensity of the plasma stream helps to direct depth during the process of multilayer volumetric heating. Prior to insertion of the handpiece, it is important to prime the handpiece by activating it against a metal instrument to visualize the plasma stream. For handpieces that have a retractable blade electrode, it is also important to ensure the blade is retracted prior to insertion. The minimal amount of helium gas (L/min) necessary to ensure a good bridge or connection to deliver the RF energy to the tissues should be utilized. The use of counter ventilation port permits egress of excess helium gas, avoidance of gas tracking and postoperative crepitus. Re-suctioning after use of the handpiece may also reduce gas related sequalae, remove liquified and fragmented cells and free fatty acids, and remove residual heated tumescent fluid that may lead to an unpredictable tissue response. The RF energy should be delivered using smooth, continuous movement of the handpiece. It can be monitored by the trans-illumination of the plasma stream in tissue, and activation should be stopped within 1 cm of the access port to prevent overheating of this area from repeated contact. There are indication lines on the handpiece shaft within 40 mm of the tip that visually guide the surgeon as to when to stop handpiece activation. A variety of handpiece lengths, diameters, flexibility and single or twin port options are available. Compressing or gathering the tissue around the handpiece with the other hand allows for directing and monitoring handpiece placement, intended plane and depth of treatment, provides more substrate to the RF energy path with each stroke, and avoids heating nontarget structures, like muscles. Tactile feedback from the non-handpiece hand offers a sense of decreasing soft tissue laxity and confirms there is no rise in skin temperature. Recall that the threshold for epidermal burns is significantly lower than the optimal temperature for collagen contraction. Error codes will provide audible warnings of gas occlusions from tip obstruction and immediately stop the delivery of RF energy in the handpiece. Deactivation of the unit and power output will occur with gas flow faults. Like bulk heating devices, the amount of time-on-tissue and energy delivered should be reduced in areas of thin skin, thin adipose layers, pre-existing scar tissue or compromised blood flow [13]. Moreover, Renuvion® is not well suited for patients with collagen vascular diseases, poorly vascularized tissue, pre-existing fibrosis or skin compromise, or lifestyles that might impair collagen remodeling such as smoking, poorly controlled diabetes, chronic NSAID use, and in patients with implantable devices that can attract the RF energy preferentially over the grounding electrode [27]. Results are likely to be limited in regions of compromised soft tissue as evidenced by open wounds, severe pendulosity, severe laxity and/or striae.

In general, Renuvion® provides reproducible, safe, well-tolerated soft tissue contraction three dimensionally and abrogates the risk of laxity. There is a 2D or linear contraction of collagen changes in the deep dermis, and 3D contraction of fascia, septal connective tissue that separates fat lobules and connects fascia to dermis, and reticular fibers that provide the framework of collagen fibers that encase fat cells [28]. Histologically, collagen bundle alignment in multiple directions is seen. The nonuniform geometry of the different components leads to a range of soft tissue remodeling results, regardless of the energy applied. Targeting the interstitial connective tissue bands without the need for full thickness dermal heating provides faster treatment times in comparison to bulk heating devices, with superior overall soft tissue contraction. Given interpatient variability in available FSN substrate, establishing clinical guidelines for consistent and predictable results is proving challenging. Recent single and multi-center chart reviews have demonstrated high patient satisfaction along with the safe and effective use of Renuvion® as an adjunct to enhance liposuction outcomes [21, 29, 30]. Consistent and reproductible soft tissue contraction was demonstrated even in the clinically challenging area of the neck area by subjective and quantitative analyses of before and after photographs [21]. Current studies are underway attempting to quantify the amount of energy deposited as kilojoules delivered per area and correlate them with resulting changes in soft tissue laxity.

8. Case selection

The following cases illustrate the effectiveness of Renuvion® technology in patients with compromised skin quality and soft tissue gliding planes because of weight fluctuations and aging. Patients were considered good candidates as they had no prior surgeries or energy-based treatments in the proposed treatment areas, desired improvements in soft tissue laxity without excisional scars, and demonstrated mild pendulosity that was felt could notably improve with the expected 30% contraction. Benefits were seen in the treatment areas of the upper arms, back bra rolls, and abdomen. The topography for liposuction and tightening was marked preoperatively in the upright patient. Portal sites were planned to permit crisscross patterns, pre-tunneling with LASER or VASER® and liposuction cannulas, allow easy strokes with the Renuvion® handpiece, as well as ventilation of residual helium gas. Sterile prep and drape with induction of general anesthesia followed. Tumescent solution utilized in all patients was composed of 1 Liter NaCl solution with 25 ml of 1% Xylocaine and 1 cc epinephrine. Residual gas was always aspirated. No worrisome clinical adverse effects such as skin compromise, erythema, etc. were seen. The patients minimized activity and used ice packs intermittently for edema control the first few days. Each was placed in postoperative compression garments for 6 weeks minimum. No unexpected sequalae were seen, including skin necrosis, seroma, fibrosis, altered sensitivity, portal burns, infection, dyschromia or long- lasting contour irregularities. Patients reported little tenderness postoperatively. All patients were pleased with their outcomes.

Figure 1 shows a 39-year-old woman who underwent a large amount of fat removal from each arm that contoured well with adjunctive Renuvion® treatment of residual laxity. She was a G1P0, nonsmoker, who had undergone an 85 lb. weight loss following gastric sleeve operation 4 years prior. She presented with a desire to reduce her arm sizes. Her current BMI was 33.08. She demonstrated grade 3 inner arm ptosis and laxity with more fat in the distal one third of each arm. She did not demonstrate axillary or forearm ptosis. She desired contouring but refused the excisional scars of brachioplasty. She demonstrated severe arm laxity but reasonable skin quality with good skin turgor, no striae nor fine wrinkling and had moderate adiposity in both proximal and distal arm regions. She was felt to be a good candidate with reasonably adherent soft tissue, suggestive of a more robust fibrous septal network substrate to target and contract with the RF helium plasma stream. A total of 700 cc tumescent solution was infused into each arm, followed by VASER® application. The 5-ring probe was used for uniform acoustic energy distribution, providing 10% energy dispersion from the 3.7 mm probe tip, and 90% from the sides. It delivered ultrasonic

Figure 1.
(a) Patient presented with excess inner arm subcutaneous fat, laxity and grade 3 inner arm ptosis, and (b) pleasing contours are seen 3 months following VASER® and Renuvion® assisted liposuction.

energy in pulsed fashion for added safety at 70% energy levels for 7 minutes in each arm. Next, a 3 mm multi-directional liposuction cannula was utilized to remove 700 cc from the right upper arm and 575 cc from the left arm, nearly circumferentially. Renuvion® was then primed and the blade retracted. The handpiece was introduced and activated upon withdrawal through multiple tissue depths subdermally and deeper near Scarpa's fascia. Tissue was gathered around the handpiece to increase uniformity, and 6 multi-depth passes were completed in a radial fashion at an approximate speed of 1 cm/sec, 70% power, with 3 L/min helium gas flow. The set of 6 passes was completed in tissue areas that were 15 cm from the port radially.

Figure 2 shows a 40-year-old woman with minimal rectus diastasis and adiposity who obtained improved abdominal appearance with the use of Renuvion® subdermal coagulation. She demonstrates longevity of effect 2 years post-op. She was a G2P2, nonsmoker who experienced 50 lb. weight fluctuations with each pregnancy. At presentation 5 years postpartum, her BMI was 20.05 and she did not have a C section scar or tissue overhang, thereby making her a suboptimal candidate for traditional abdominoplasty. Since the abdomen has more fibrous septal network bulk to recruit, it was felt that the predictable fibrosis, remodeling and collagen contraction offered by Renuvion® subdermal coagulation could offset any exacerbation of laxity from liposuction. A total of 750 cc tumescent solution was infiltrated between the upper (above the umbilicus) and lower (below the umbilicus) abdomen, and 250 cc into each hip and waist area bilaterally. The VASER® was utilized at 60% power in pulsed mode until there was no resistance. Liposuction was completed with 50 cc lipoaspirate from the upper abdomen, 150 cc from the lower abdomen, and 100 cc from each hip and waist bilaterally. Next, the Renuvion® handpiece was set at 60% power, 2 L/min gas flow and 6 passes were completed in a radial fashion at 1 cm/sec. This was done in the upper abdomen, repeated in the lower abdomen, and each waist and each hip, 15 cm from the ports in all directions. Again, tissue was gathered with the non-dominant hand to increase uniformity and treat tissue at different depths. She demonstrated contraction as early as one week, and a two year progressive improvement, purportedly from new collagen ingrowth within the connective tissue stroma.

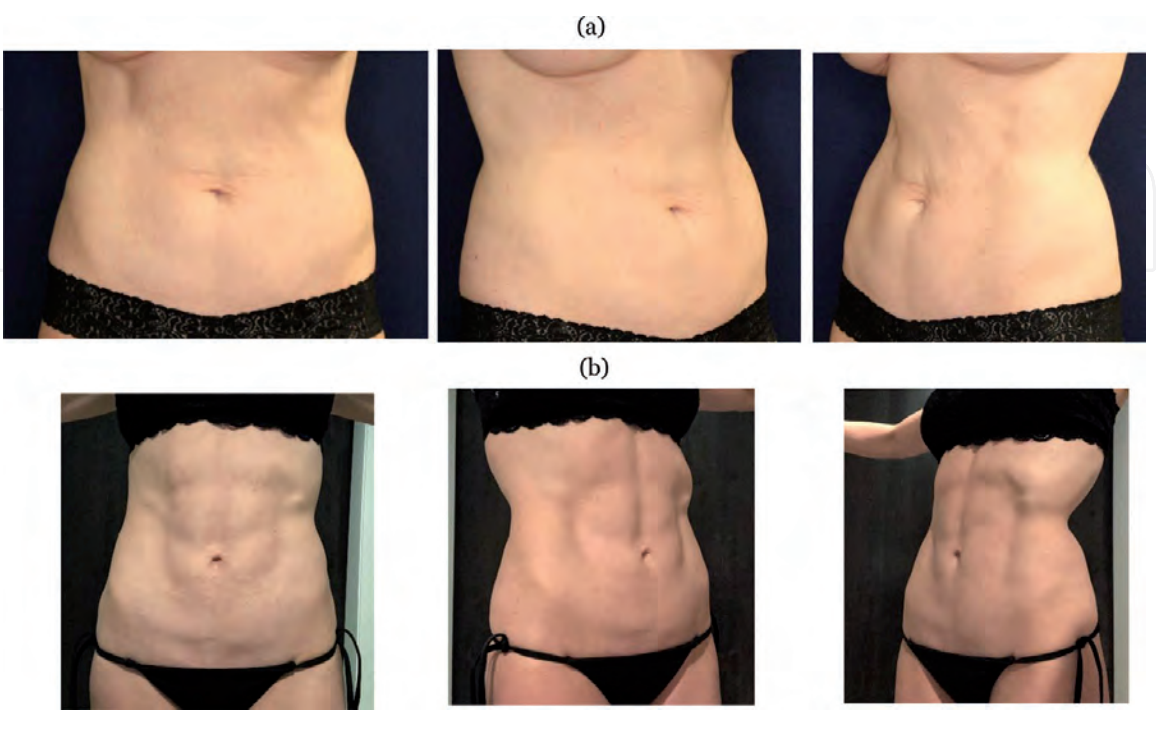

Figure 2.
(a) Patient presented with minimal abdominal subcutaneous fat and skin laxity, and (b) pleasing contours are seen 2 years following VASER® and Renuvion® assisted liposuction.

Figure 3 shows a 63 year old woman with marked skin laxity, poor skin quality and little adiposity throughout the arm, forecasting a poor result to traditional RF technologies. She obtained pleasing tissue contraction following Renuvion® subdermal coagulation. She was G3P2, nonsmoker with grade 3 inner arm ptosis and BMI of 20.50. She too desired improvement in her arm contours but refused brachioplasty. She did not have axillary or forearm ptosis. It was plausible that older skin contours would result as laxity would prevail following any fat removal without thermal contraction. She too would not accept lengthy brachioplasty scars and was willing to proceed with Renuvion® subdermal coagulation. The approach included near circumferential discontinuous soft tissue release, liposuction, and delivery of Renuvion® for subdermal coagulation of the superficial fascial system and was able to provide good contouring. A total of 25o cc of tumescent solution was infused into each arm, followed by VASER® application. The 5 ring, 3.7 mm VASER probe was utilized at 60% power in pulsed mode, for 2 minutes in each arm. The 3 mm multidirectional liposuction cannula removed 125 cc of fat from each arm. Given her thin skin, little adiposity, and probable minimal target fibrous substrate, Renuvion® energies were reduced to 50%, 4 lpm gas flow and 6 passes were completed in all directions for 15 cm from the port. Similar to the other patients, the tissue was gathered and the handpiece speed of 1 cm/sec was maintained. End hits were avoided by remaining deep and maintaining constant handpiece motion.

Figure 4 shows a 59 year old woman with marked laxity and curtaining of back tissue that achieved significant improvement following treatment with Renuvion®. She was a G3P2, nonsmoker who had undergone an 85 lb. weight loss following a gastric sleeve operation 3 years prior. At presentation, her BMI was 32.92. A total of 750 cc of tumescent solution was infiltrated into each waist, hip, and bra roll area bilaterally. The VASER® 5 ring, 3.7 mm probe was utilized at 90% power in pulsed mode for 5 minutes on each side. The lipoaspirate totals from each side were 500 cc. To assist flattening and resolution of the curtaining, Renuvion® was utilized at 60% power 4 lpm, 6 passes to the waist, 6 passes to the waist and hip and 6 passes to the bra roll on each side, 15 cm radially from each port. The techniques detailed in the previous patients were applied here.

These cases illustrate therapeutic and beneficial soft tissue contraction in patients that either were not a candidate for excision or who were but did not accept the concomitant scars of tissue excision. The use of Renuvion® effectively extended liposuction as an option to a non-traditional patient group of large weight loss patients that demonstrate damaged FSN. As all patients were satisfied and there have been no reoperations, the question of whether there is potential for further improvement or longevity with a subsequent Renuvion® treatment remains unanswered.

Figure 3.
(a) Patient presented with little inner arm subcutaneous fat, laxity and grade 3 inner arm ptosis, and (b) pleasing contours are seen 3 months following VASER® and Renuvion® assisted liposuction.

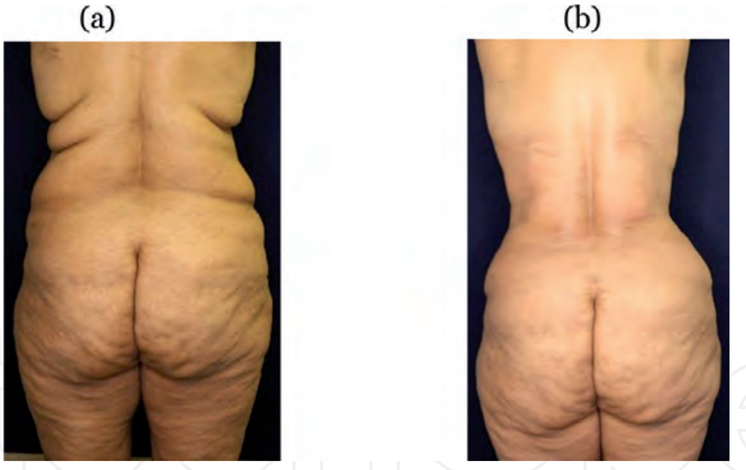

Figure 4.
(a) Patient presented with excess back, waist and hip subcutaneous fat, laxity and curtaining of tissue, and (b) pleasing contours are seen 3 months following VASER® and Renuvion® assisted liposuction.

9. Conclusion

Renuvion® technology transfers heat to the subdermis and connective tissue matrix through the ionization and rapid neutralization of helium gas atoms and through passing RF current through the resistance of the tissue (Joule heating). The RF helium plasma technology offers the contemporary, judicious liposuction surgeon a way to abrogate host skin laxity, and coagulate adipose, connective, and vascular tissue, thereby reducing traditional liposuction downtime associated with discomfort, ecchymosis, and edema. It provides an option for body contouring in patients that do not qualify for or want tissue excision, who cannot achieve skin tightening with other modalities or who present with unresolved laxity following excisional procedures. The addition of energy-based technologies to minimize traumatic fatty tissue extraction, expose and contract the total tissue collagen burden is a useful adjunct to enhance traditional liposuction results. The changes in the mechanical behavior of connective and deep dermal tissue from Renuvion® result in thermal collagen denaturation and contraction that beneficially reduces volume and surface area of the soft tissue envelope. This makes it a viable alternative to dermatolipectomy procedures and their concomitant risks, scarring and protracted recovery. Future studies will establish optimal energy levels, treatment time on tissue and objective measures of clinically apparent soft tissue contraction and reduced skin laxity.

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Conflict of interest

The author has no commercial, proprietary or financial interest in the products or companies described in this chapter.

- *The Renuvion® APR Handpiece is intended for the delivery of radiofrequency energy and/or helium plasma where coagulation/contraction of soft tissue is needed. Soft tissue includes subcutaneous tissue.*
- *The Renuvion APR Handpiece is intended for the coagulation of subcutaneous soft tissues following liposuction for aesthetic body contouring.*
- *The Renuvion APR Handpiece is indicated for use in subcutaneous dermatological and aesthetic procedures to improve the appearance of lax (loose) skin in the neck and submental region.*
- *The Renuvion APR Handpiece is intended for the delivery of radiofrequency energy and/or helium plasma for cutting , coagulation and ablation of soft tissue during open surgical procedures.*
- *The Renuvion APR Handpiece is intended to be used with compatible electrosurgical generators owned by Apyx Medical.*

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