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Not all Radiofrequency Devices Are Created Equal: A Thermal Assessment

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Over the past 20 years, radiofrequency has emerged as a leading technology to achieve nonexcisional soft tissue contraction.[1–3] A variety of delivery methods of radiofrequency are currently available, including monopolar, bipolar, multipolar, fractional, and plasma-driven.[1,4–9] Combination technologies (ie, laser, vacuum) have also been developed to change the impedance characteristics of tissue and influence thermal delivery patterns.

Multiple studies have demonstrated that soft tissue contraction of 30%–40% can be achieved with radiofrequency-assisted liposuction; as opposed to approximately 10% with mechanical liposuction alone.[10] The degree of soft tissue contraction after thermal injury has been shown to follow an Arrhenius relationship of temperature versus time.[10,11] (**See figure, Supplemental Digital Content 1,** which displays the (a) soft tissue contraction: Arrhenius time versus temperature relationship, and (b) bipolar radiofrequency. **http://links.lww.com/PRSGO/B911**.)

This relationship indicates that a higher temperature exposure for a shorter time period provides equivalent soft-tissue contraction to a lower temperature exposure for a longer time period. For example, collagen heated at 65°C for 120 seconds will provide a significant contraction, equivalent to a temperature of 85°C for approximately 0.044 seconds.[11]

Two radiofrequency delivery methods that differ significantly in temperature versus time philosophy are plasma-driven radiofrequency (J-Plasma/Renuvion; Apex Medical) and bipolar radiofrequency (Accutite, BodyTite, FaceTite; InMode). (**See Video 1 [online],** which displays the comparison thermal imaging video of body and face treatment of monopolar versus bipolar radiofrequency.) Plasma-driven radiofrequency first became popularized with J-Plasma/Renuvion in early 2012 when it received 510K FDA clearance for cutting, coagulation, and soft tissue ablation.[10] This device uses helium gas plasma, fueled by an electrical current to treat tissues at high temperatures for short periods of time. The current delivered is low, resulting in minimal depth of thermal effect and prevention of overheating tissue when performing multiple passes. Because plasma-driven radiofrequency treats for short time-intervals, the surrounding treatment sites remain at relatively cool temperatures. Also, the volume of un-ionized helium gas in the treatment space serves as a cooling system to avoid prolonged heating. The plasma-driven electrical current travels 360 degrees from applicator tip without a focused direction and will preferentially travel through tissues with the least resistance. The benefit of plasma-driven rapid heating and cooling is that there is a relatively low epidermal burn risk. This is supported by surface temperatures rarely exceeding 38°C during treatment.[12] However, the limitations of this method of radiofrequency delivery are that the low current is unable to penetrate higher impedance tissues, leading to minimal depth of effect. Also, as the device passes into proximity of previously treated tissue, the energy will follow the path of least resistance (lower impedance). However, ideally the structures with high impedance (adipose tissue and fibroseptal networks) should be treated for optimal soft tissue contraction.

In contrast, the latest generation bipolar radiofrequency with internal/external temperature monitors as well as impedance control was introduced in 2012 by Invasix (Yokenam, Israel). (**See figure, Supplemental Digital Content 1, http://links.lww.com/PRSGO/B911.**) The device utilizes a small cannula placed underneath the skin to gradually bulk-heat soft tissue between the two electrodes in a radiant distribution. The controlled directionality of the radiofrequency energy (internal electrode to external electrode) focuses thermal energy across tissues with higher impedance (ie, adipose tissue, fibroseptal networks, reticular dermis). This volumetric heating is more gradual than plasma-driven

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radiofrequency and consequently maintains a wide heat signature for a longer duration after treatment (up to 60 min). Early studies showed a 50% improvement in upper arm soft tissue laxity and 36% skin surface area reduction at 1 year.[12] Target temperatures in the subcutaneous tissue range between 65–70°C for 1–2 minutes. The external temperature probe provides an added layer of safety to ensure that subdermal temperatures remain within 38–40°C, as the threshold epidermal burn temperature is lower than the optimal temperature for collagen contraction.

There are limited data comparing clinical outcomes of different radiofrequency delivery methods. It is the authors' opinion that volumetric heating in a bipolar direction is the optimal technology for soft tissue contraction. As evidenced by near infrared thermal imaging (FLIR), prolonged and evenly distributed heating at the skin surface with BodyTite/FaceTite bipolar radiofrequency (InMode) functions to maintain thermal injury and contract target tissues (ie, fibroseptal network, reticular dermis). In contrast, rapid heating at high temperatures has been associated with rapid cooling, collagen recoil, and loss of contractile effect. Of note, the near infrared camera used only provides surface temperature recordings as a surrogate for internal temperature, and has limitations in this regard. Early concerns over safety and risk of burns with bipolar radiofrequency volumetric heating have been mitigated by newer generation devices with internal/external temperature probes and impedance monitors. Radiofrequency has emerged as a safe and effective non-excisional method of soft tissue contraction. More data are needed to elucidate differences between different radiofrequency technologies for optimal safety/efficacy.

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