Radiofrequency in aesthetics skin treatment: Classification and modalities.

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Editorial

The term 'radiofrequency' makes reference to electromagnetic signals whose frequencies range from 30 KHz to 1 GHz in the electromagnetic spectrum [1]. These are mainly characterised by their capacity to generate thermic effect when trespassing biological tissue [2]. This process has been related to therapeutic and aesthetic purposes for more than a century [3,4].

Jacques D'Ansorval (its discoverer) attributed therapeutic properties to it thanks to an increase in tissue metabolism when these tissues are heated [2]. As a result, vasodilation and an increased blood influx in the area may be observed [5]. Analgesic properties were further attributed due to a saturation of local thermoreceptors, which modulate afferent nociceptive signals through gate control mechanisms [5,6].

Concerning aesthetics, its skin rejuvenation properties due to an increase in oxygenation by vasodilatation as well as the activation of collagen repair proteins or heat shock proteins (HSP) were also questioned [7]. These proteins are sensitive to heat and are liberated as a response to thermal damage to collagen tertiary structures [1]. In addition, they contribute to their reparation and considerably improve the initial state of collagen in case of degeneration [1]. At the same time, these proteins stimulate collagenesis, which in turn favours the thickening of skin support tissue [7]. As a consequence, these mechanisms seem to be highly useful when treating flaccidity, wrinkles and skin aging [1].

Additionally, the secondary structure of collagen would be affected if the 42°C threshold temperature for collagen was surpassed [8]. This would produce a retraction of protein chains, which initially would produce a tensing effect of dermis supporting structures [1]. Nevertheless, this situation does not favour the release of HSP repair proteins, as they are not capable enough to repair such damage. In addition, it may have a perishable effect –it would in fact be annulled when macrophages completely eliminate debris produced by damaged collagen [1]. This leads to a new situation of dermis conjunctive tissue support loss which may in turn increase flaccidity [8].

It is therefore obvious that the utility of radiofrequency at long term lies on its precision to heat target tissue without provoking an irreparable degradation [4]. However, a wide range of radiofrequency devices presenting different application modalities, transmission mechanisms and dosimetry control are currently available. As a result, it is necessary to classify these systems according to their subsequent effects when their different characteristics are concerned.

The aim of this article is to establish a classification of radiofrequency devices used in aesthetics according to their application modalities, signal transmission, dosimetry control and signal processing.

Application modalities

Three types of application modalities are shown below:

Monopolar modalities: There is a single pole which acts as an aerial, what means that it does not need a receptor to emit the signal. The receptor pole will be the tissue on which the signal is applied. The more the lateral distance comprised between the tissue to be treated and the emission focal point, the lesser the effect [1]. Great focalisation is possible due to this system, as there is no energy transmission between different poles [9]. This modality must not be confused with the incorrectly called monopolar with "neutral" plate, which is bipolar as without the plate the device does not work (what means that plate is the receptor pole) [3].

Bipolar modalities: There is an emitting pole and a receptor pole. In this case, energy transfer is produced when a conductive agent is applied [3]. According to the distance between both poles, the following types may be distinguished:

Proximal bipolar modalities: Both poles are intimately connected. As a result, energy is directly transmitted from one pole to another through a small contact surface area [3]. This process leads to high density levels of energy in the area. Additionally, this energy generates heat when applied to skin, which in turn provokes its heating by conduction [10] –the most heated body (applicator with both poles) transferring heat to the coldest one (skin). As the latter is highly resistant to electricity, these systems are mainly effective on surface [10] –their capacity to deepen may be limited due to the activation of 45°C skin thermal damage threshold [8].

Distal bipolar modalities: In this case, both poles are separated and biological tissue acts as a conducting element between them [9]. Concerning their positioning, coplanar (two objects lying in the same plane) and contraplanar (opposite sides) collocation techniques should be mentioned here [3]. Whereas the first one produces no effect in depth, the second one consists on a transmission of energy through all tissue poles until reaching the receptor pole [3]. However, this does not mean that an effect is produced on all these planes, as this effect will be determined by other factors such as the transmission mechanism, frequency, intensity, etc. [10].

Multipolar modalities: Also known as tripolar, pentapolar etc., this is actually a variation of bipolar type, nevertheless it is included in a different group for didactic reasons. It is in fact a bipolar type but in this case one of the poles presents more than one output (three outputs in case of tripolar, five in case of pentapolar…) [3]. As a consequence, the contact surface between both poles may be further reduced while an increase in energy density is produced. This system would be therefore considered as proximal bipolar type and will either produce no effect in depth [10].

Transmission mechanisms

Three main types are explained below:

Resistive or conductive mechanism: It depends on Joule's law. The amount of heat produced on tissue will be obtained by multiplying the square of signal intensity, the time of application and the tissue resistance to electricity – The latter being the variable which depends directly on the tissue [1]. From this law, it can be concluded that those tissues with higher resistance levels to energy will present higher temperatures when compared to more conductive ones –tissues such as skin and fat will rapidly be heated with this transmission type whereas this heating process will be much slower in the case of muscle and fascia [3]. Due to the fact that epidermis is highly resistant to electricity, this transmission type does not produce deep effects, as these are limited by the previously mentioned skin thermal damage threshold. It is usually presented with metallic emission surface applicators and requires the presence of conductive substances to be applied.

Capacitive or resistive recoated mechanism: In this variable of resistive transmission, the emitting element is coated with a material which reduces impedance during the application process as well as the electrolytic effects produced by contact between high frequency emitting metals and skin. As its thermal effects are less important, this transmission type is therefore used to reach more depth while decreasing the thermal effect produced on surface.

Dielectric or capacitive dielectric mechanism: It is based on the condensation behaviour of biological tissues –that is, elements which have the capacity to recharge energy and release it later during the discharging phase [11]. This phenomenon follows the Condensers Law. This transmission type requires that all the elements in the circuit behave as condensers [12]. As a result of this, the application of a dielectric substance (100% pure vegetable oil) during the interphase between applicator and skin is required. It makes possible a deep energy transfer without heating surface tissues with a consequent protection of epidermis [11].

Dosimetry monitoring

Among the current existing systems, three procedures to control dosimetry in order to avoid possible skin burns and protein alterations have been chosen to be specified in this section.

Patient feedback: It is the patient the most appropriate person to determine if the thermal perception is unpleasant and who informs the physiotherapist [13]. This information is crucial in order to regulate the emissions produced by the system. Nevertheless, it is a poor system which frequently proves insufficient.

Measurement of temperature on surface: There are several systems with applicators containing a thermometer with infrared measurement. These are used for a constant measurement of skin superficial temperature [1]. This system may be useful so as to avoid damage on surface; however, it does not provide any information about temperatures of deeper tissues.

Calculation of dosimetry: it is based on the calculation of the temperature of target tissues, taking into account their initial temperature, the temperature to be reached, the intensity of emission, the volume of tissue to be treated and energy dispersion [4]. This is the most suitable option when non superficial tissues are concerned. Nevertheless, the calculation of dosimetry for each treatment may seem a complex process –this is why systems usually include it previously programmed.

Signal processing

Concerning the electromagnetic signal processing emitted by the device, two groups will be explained below:

Analog signal processing: A potentiometer allows a manual regulation of the intensity of heat produced by the system. These systems usually emit only one continuum frequency [13]. What is modified by the potentiometer is the signal width or peak to peak voltage.

Digital processing: There is a microprocessor which controls emission according to its previous programming. This makes possible not only the increase in the range of frequencies but also the reduction of thermal effects [4] without reducing the signal intensity when pulsing the wave as well as the modulation of electromagnetic signal so as to produce piezoelectric and resonance effects [2].

Conclusion

Radiofrequency may be an especially interesting tool for aesthetic skin treatment. However, currently available systems vary greatly. Whereas capacitive or resistive systems may be relevant for superficial treatments when used with dosimetry monitoring, dielectric ones seem to be more suitable when both depth and surface are concerned.

Due to the great variability observed in frequencies, pulses and emissions and because some manufacturers are not very clear about the emission parameters of their systems, further studies will be required in order to determine which parameters are most adequate for each pathology type and tissue to be treated.

***Table 1.** Radiofrequency clasification summary.*

Application modalities	Mono polar Bipolar Proximal Distal Multipolar
Transmission mechanism	Resistive/Conductive Capacitive/Resistive recoated Dielectric/Capacitive Dielectric
Dosimetry monitoring	Patient feedback Measurement of surface temperature Calculation of dosimetry
Signal processing	Analog signal processing Digital processing

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