Electrosurgical Peeling (peeling by high frequency cellular volatilization)

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Abstract

The author reports his experience with electrosurgical peeling based on his previous experience with CO_2 laser and high frequency cautery. He also explains each procedure according to the technique being utilized, namely physical peeling (CO_2 laser, radio-frequency, dermal abrasion, etc.) and chemical peeling (with weak and strong acids and other abrasive agents), as well as according to depth of peeling (superficial vs. deep). This work addresses the indications of facial peeling for esthetic purposes. Moreover, it addresses the systematization of the electrosurgical peeling, which applies a basic principle similar to that of CO_2 laser (intracellular vaporization - cellular explosion phenomenon). Basic concepts of electrosurgery are discussed with emphasis on mechanisms of action of the volatilization equipment. Post operative follow-up evaluation of patients submitted to superficial and deep peeling is also discussed in detail. The good results can be attributed not only to effects of high frequency (radio frequency), but also to a rigorous patient selection and close follow-up lasting for 1 year.

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Introduction

Electrosurgery is a process of tissue cutting and coagulation that utilizes a high frequency electric current. High frequency surgery should not be mistaken for "diathermy", electric cauterization, spark generation or similar methods. It consists of a non traumatic method of tissue cutting and gentle coagulation. The results of this cutting method known as high frequency section are obtained without pressure or crushing of tissue cells. This effect is results from the heat that is generated through the electrical resistance of tissues when a current is produced by high frequency waves. The heat makes the intracellular water boil, thereby causing an increase in intracellular pressure and rupture of the cell membranes. This process is called cellular volatilization.

Occasionally, electrosurgery and electrosurgery generators are referred to by different names. In Europe, electrosurgery is frequently called "surgical diathermy". In the US, electrosurgery generators are called "Bovie generators" or electrocautery machines. Because the wave length utilized in electrosurgery is close to that of FM radio, they are also called radiofrequency waves. Electrosurgery as a method of cutting and coagulation of tissue was first utilized by physicians in the late XIX century. In the 1920's, Harvey Cushing and W.T. Bovie turned this in a very popular method after having success with almost bloodless neurosurgical procedures. W.T. Bovie is generally credited with the discovery about how different wave forms might influence the effects on tissue. Bovie developed two electrosurgical generators that were designed to either cut like a scalpel or coagulate tissues for hemostasis.

Bovie's basic electrosurgical equipment with separate currents for cutting and clotting was utilized in the US between 1930 and 1960 with only minor alterations. In the 1970's there was a step forward with the development of

modern electrosurgical generators. These devices were able to generate complex wave forms and, at the same time, had excellent safety features. The modern versions of electrosurgical techniques are currently utilized in delicate surgical procedures with great safety.

Technical Aspects

Previous experience with the use of CO_2 laser in plastic surgery has provided the basis for further clinical research on the use of high frequency cellular volatilization.

For the past 3 years, we have been utilizing the electrosurgery equipment[17-19] with excellent results. This cutting device has been utilized in several surgical procedures such as reduction mammoplasty, dermolipectomy, ritidoplasty and correction of skin lesions and abnormal scarring. The procedure results as well as clinical investigation outcomes have been reported in several conferences and medical journals. This experience has allowed a more effective utilization of electrosurgical peeling procedures. However, it is important to stress the need for surgeons to be familiar with basic knowledge of physical phenomena involved in electrosurgery.

A - Basic Concepts in electrosurgery and bases of electromagnetism

The electrosurgical techniques are divided in two main categories: monopolar and bipolar. In monopolar procedures, the electric current flows from the active electrode through the patient's body into the return electrode. In bipolar procedures, the electromagnetic wave flows from an active electrode to another active electrode through a small volume of tissue interposed between them.

In order to extend the biological effects of the electromagnetic wave on biological tissues, it is important to review some basic definitions in electricity:

- Voltage (Volts): power required to move electrons.
- Current (Amperes): electron flow through tissue.
- Resistance (Ohms): resistance to electron flow through tissue.
- Power (Watts): the amount of energy produced or consumed in a given period of time.

The modern electrosurgery equipment produce very high frequency electromagnetic waves from 350,000 cps (cycles per second or 350 kHz - Kilohertz) up to 4,000,000 cps (4 mHz - Megahertz). The wave utilized in electrosurgery is similar to that of FM radio and, therefore, are often called radio frequency waves. In addition to relatively specific cutting and coagulation currents, modern equipment of electrosurgery produce mixed waves (blended), which combine good cutting effects with moderate coagulation effects. It is important to mention that, in almost any electrosurgery equipment, the coagulation effects obtained by a mixed wave is not affected by the adjustment of the cutting power. In other words, the final hemostasis effect obtained with such waves does not depend on the cutting power.

B - Effects of radio frequency waves on biologic tissue

There are three main effects caused by a radio frequency waves passing through biologic tissues:

- The faradic effect: this is not usually observed with modern electrosurgical equipment that reach frequencies above of 300 kHz.
- The electrolytic effect: caused by the polarization of ions in a tissue. When an alternate current is applied to a tissue composed mainly by water and electrolytes, the ionized particles in the tissue will vibrate, thereby increasing kinetic energy. Due to the high frequency applied through alternate current, the ionized particles will move only slightly, but the kinetic energy will ultimately lead to a temperature increase in the tissue (Figure 1).
- Thermal effect: there are several factors that influence the mode of conduction of heat through a tissue. Water is an excellent medium to maintain thermal balance in a tissue because of its constant vaporization temperature. Another important factor is the vasculature of the tissue, since circulation helps dissipation of heat. The effects caused by a temperature rise in biologic tissue will depend both on the final temperature that is reached and the total duration an elevated temperature is maintained.

  When the temperature rises slowly, the tissue will dry out and there will be coagulation of constitutive proteins. In contrast, when the tissue is quickly heated to high temperatures, neither vaporization or thermal transference will effectively dissipate heat, and therefore, tissue temperatures will rise above 100 °C. Intracellular water vaporization will produce a volume

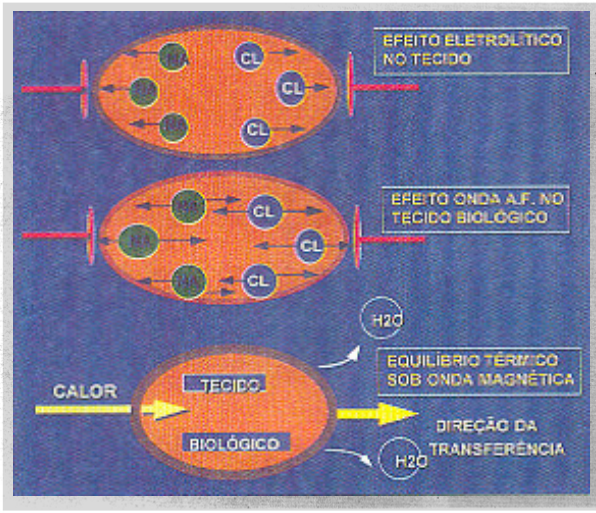


***Fig. 1** - Schematic representation of the electrolytic effect. The high frequency wave applied to biologic tissue will provoke an abrupt rise of intracellular temperature due to high frequency of the alternate wave; the ionized particles do not move much, but the kinetic energy is sufficient to generate heat.*
***Fig.1** - Representação esquemática do efeito eletrolítico. A onda de alta freqüência, no tecido biológico, provoca uma elevação brusca de temperatura intracelular, devido à alta freqüência da onda alternada; as partículas ionizadas não se movem por grandes distâncias, mas a energia cinética produz aumento da temperatura intracelular.*

increase and subsequent cell membrane rupture due to excessive internal pressure (Figure 2.)

Several factors, including water content, will influence the electrical resistance tissues. The electrical resistance of dry tissue is much higher than that of a well hydrated one. One calorie is defined as the quantity of heat necessary to raise the temperature of 1 cm^3 of water by 1°C.

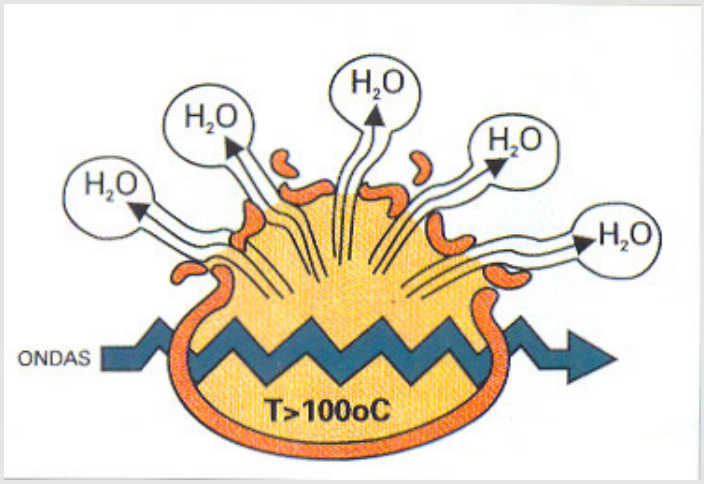
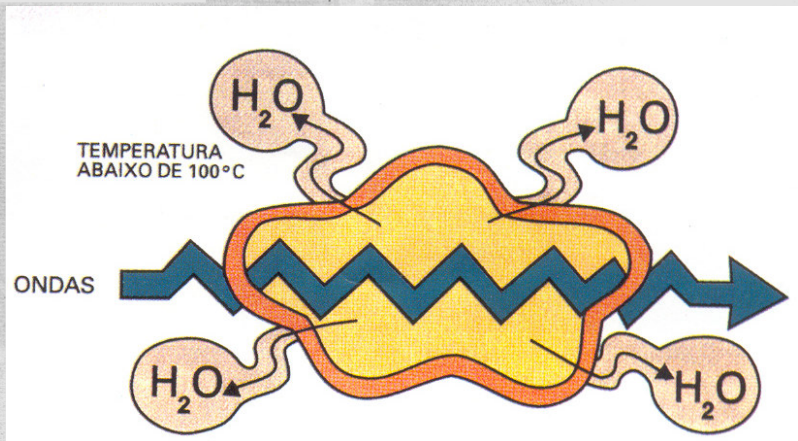


***Fig. 2** - Intracellular water vaporization (cellular explosion). The cytoplasmic temperature elevation leads to boiling of intracellular water and ultimately a cellular volatilization phenomenon.*
***Fig. 2** - Vaporização da água intracelular (explosão celular). Com a elevação da temperatura citoplastmática, ocorre o fenômeno da volatilização celular pela evaporação da água.*

***Fig. 3** - Denaturation of tissular proteins - Desiccation process reached by slow elevation of intracellular temperature to levels below 100 °C. The cytoplasmic proteins will coagulate.*
***Fig. 3** - Desnaturação proteica dos tecidos - Processo de dissecação, atingida quando a temperatura interna da célula é lentamente aumentada a menos de 100°C. As proteínas citoplasmáticas se coagulam.*
(Fotos 1,2 e 3 gentilmente cedidas por LOKTAL MEDICAL ELETRONICS).



Paciente 1

***Fig. 4** - Pre-operative aspect: indication for superficial regional peeling: peri-oral and frontal.*
***Fig. 4** - Aspecto pré-operatório: Indicação de peeling regional superficial: peribucal e frontal.*

***Fig. 5** - Facial edema after peeling procedure.*
***Fig. 5** - Aspecto do edema facial no final do ato operatório.*

***Fig. 6** - Postoperative day 3. Note the crust formation on treated areas.*
***Fig. 6** - Pós-operatório de 3º dia. Notar as crostas sobre as regiões tratadas.*

***Fig. 7** - Postoperative day 10. The crusts have peeled off. The erythema is still quite evident.*
***Fig. 7** - Pós-operatório de 10º dia. As crostas já foram eliminadas. Eritema ainda bem visível.*

***Fig. 8** - Postoperative day 40. The erythema persists, even though to a lighter intensity.*
***Fig. 8** - Pós-operatório de 40º dia. O eritema, apesar de bastante diminuído, ainda persiste.*

***Fig. 9** - Three months post surgery. Erythema practically resolved.*
***Fig. 9** - Pós-operatório de 3 meses. Praticamente sem vestígios do eritema.*

***Fig. 10** - Six months post surgery: final result (broad view).*
***Fig. 10** - Pós-operatório de 6 meses: resultado final (vista geral).*

***Fig.11** - Six months post surgery: final result (close up view).*
***Fig. 11** - Pós-operatório de 6 meses: resultado final (close-up).*

Paciente 2

***Fig. 12** - Preoperative aspect: indication for deep peeling.*
***Fig. 12** - Aspecto pré-operatório. Indicação de peeling amplo profundo.*

***Fig.13** - Final aspect at the end of the procedure. Note facial edema.*
***Fig. 13** - Aspecto no final do ato operatório. Notar edema facial.*

***Fig. 14** - Postoperative day 3. Note the crusts on treated areas.*
***Fig. 14** - Pós-operatório de 3º dia. Notar as crostas sobre as regiões tratadas.*

***Fig.15** - Postoperative day 10. Crusts resolved completely. Remarkable facial erythema.*
***Fig. 15** - Pós-operatório de 10º dia. Crostas totalmente eliminadas. Eritema bem acentuado.*

***Fig.16** - Postoperative day 40. Still notable facial erythema.*
***Fig. 16** - Pós-operatório de 40º dia. Eritema ainda acentuado.*

***Fig. 17** - Three months after surgery: note residual erythema.*
***Fig. 17** - Pós-operatório de 3 meses. Notar, ainda, presença de eritema residual.*

***Fig.18** - Six months after surgery: Final result (frontal view). Note the disappearance of the erythema and the smooth aspect of the skin.*
***Fig. 18** - Pós-operatório de 6 meses. Resultado final (vista frontal). Notar o alisamento da pele e desaparecimento do eritema.*

***Fig.19** - Six months after surgery. Final result (lateral view). Note the smooth aspect of areas around the mouth and eyes.*
***Fig. 19** - Pós-operatório de 6 meses. Resultado final (vista lateral). Notar o alisamento principalmente das áreas periorificiais (lábios, olhos, "pés-de-galinha").*

C - Desiccation

Desiccation is usually obtained when the intracellular temperature is slowly risen to less than 100°C. The water evaporates and the intracellular proteins coagulate. This phenomenon occurs with low levels of energy (Figure 3).

D - Surgical Cutting

The process of electrosurgery is identical to that utilized by CO_2 laser. Cutting will happen when there is a fast intracellular temperature elevation and subsequent vaporization. Both with electrocautery and CO_2 laser, the intracellular temperature will raise above 100 °C within microseconds. Under these conditions, the overheating of tissue water will lead to pressure elevation of several atmospheres. The consequence of that is the generation of intracellular shock waves that will ultimate lead to destruction of tissue. Electrosurgical cutting will only happen with high energy levels. Another feature of electrosurgical cutting refers to the high safety profile. Tissue burning by electrodes or plates will virtually never happen.

Materials and Methods

Patient population included both men and women, all Caucasian, with an age ranging from 15 to 60 years. Baseline diagnoses included benign skin problems (correction treatment) and cutaneous aging (esthetic treatment). For esthetic treatment we have selected patients with fair eye color and pure ethnic features.

Patients underwent high frequency volatilization peeling according to specific indications in each case. Patient selection with esthetic goals according to the following groups:

- *Superficial creases (wrinkles) in specific facial regions:*
  a- peri-occular
  b- peri-oral
  c- frontal
- *Superficial creases (wrinkles) of broad facial regions:*
- *Areas containing tattoos*

When target areas were anesthetized with 0.2% Lidocaine solution containing adrenaline 1/2,000,000 (total volume for the entire facial surface of 100 cm^3) peeling of specific planned areas was easily accomplished with the utilization of high frequency cellular volatilization with intensity of 35%.

The procedure was performed in an outpatient setting under sedation with Midazolan 15 mg, given 20 minutes before. When the face is wet by normal saline, a light pressure applied to the skin through fast scanning motion will make the superficial skin layer detach easily. Underneath the skin layer that was removed, it appeared a white layer that contains no blood, which was gradually dried with gauze. The approximate total duration of a peeling procedure was 60 minutes.

At the end of the procedure, solid Vaseline is applied to the face. When patients complain of burning, usually 3 hours after the procedure, lidocaine jelly is applied for 1 hour, followed by hydrating skin lotions.

After total facial peeling, facial swelling was maximal in 24 hours, persisting for 3 days and gradually diminishing until the 6th day. A characteristic crust formation seen after deep peeling was usually noted on the 3rd day. With application of hydration lotions containing sunblockers, the crust slowly peeled off being finally eliminated by the 10th postoperative day. The post peeling erythema, as seen with other deep peeling procedures, lasted for 4 to 6 months. In cases of peeling applied to small areas, the erythema resolved within 3 months. Hydrating lotions and sunblockers were prescribed until there was complete disappearance of post peeling erythema.

The results with removing tattoos were not satisfactory, even though selected patients had superficially located, low density dark pigments. We believe that for such cases, Rubilaser, through explosion of pigments without skin lesion, provides the best treatment.

All patients were followed for 1 year after treatment was completed.

Discussion

We utilize the following classification for the various types of peeling:

A - According to the agent utilized on the skin:
- Physical peeling:dermal abrasion cellular volatilization - CO_2 laser high frequency electrosurgical device;
- Chemical peeling: acidic agents other abrasive agents.

B - According to the depth of peeling:
- Superficial peeling
- Deep peeling

The outcome depends directly upon the depth of peeling, regardless of the agent utilized on the skin. Thus, the recovery period of post surgical erythema after superficial peeling was much shorter than that observed for deep peeling (4 to 6 months).

Amongst superficial peeling agents we include weak acid agents (retinoic acid, glycolic acid, etc.) and amongst deep peeling agents such as trichloroacetic acid (Obagi treatment, etc.). It is important to note that physicians that have experience with such agents canobtain peeling of several depths through the utilization of chemical combinations. It is beyond the scope of this paper to comment on such techniques.

Physical peeling techniques (CO_2 laser or high frequency electrosurgical device) can provide both superficial and deep peeling.

Results

Results with removing tattoos were not satisfactory. In contrast, we obtained good results with treating superficial skin wrinkles, both localized and diffuse.

The techniques that were utilized for electrosurgical peeling are as follows:

✓ Superficial Peeling: 25% of total power capacity, "S"or "N" electrode (according to the area one wants to treat), fast scanning motions.

✓ Deep peeling: 35% of total power capacity, "P" or "N" electrode, fast scanning motions.

The depth of peeling has to accord to each specific case. For instance, if superficial peeling is utilized in an area where deep peeling would have had better effects, the result can be quite poor. Even though the erythema will resolve in a shorter time, causing great enthusiasm, the long term results will be unsatisfactory.

Active patient participation and compliance, as well as psychological preparation, are key factors in the overall success of deep peeling procedures due to the long lasting erythema. When basic rules are not followed (avoid prolonged exposure to sun, always utilize hydrating lotions, regular office visits, etc.) complications such as hyper or hypochromatic changes may arise. These complications are not always amenable to treatment.

Another important aspect, is patient selection. Thus, patients who have dark skin or are of mixed ethnicity, may have worse outcome if not submitted to a careful pre-treatment analysis. Poor screening, partly consequent from the influence of widespread enthusiasm with peeling procedures, may lead to bad results and unhappy patients.

The indications of peeling procedures for benign skin conditions are currently under investigation by our team and will be reported in the near future in medical journals.

Conclusions

The clinical experience shows that results obtained through CO_2 laser and electrosurgical devices (cellular volatilization peeling), both physical peeling techniques, are similar in many ways:

1. The superficial peeling has a shorter period of post-surgical erythema.
2. The results of superficial peeling, especially when applied to the whole face, is usually worse than what is obtained by deep peeling.
3. The superficial peeling is as effective as the deep peeling when applied to small skin areas around the eyes and mouth, and the post-surgical erythema is less.
4. The deep peeling has better results when utilized diffusely over larger facial areas (with exception of what is mentioned in item 3).
5. The deep peeling causes persistent erythema for up to 6 months, after which the results are better than those obtained by superficial peeling.
6. The application of deep peeling in areas surrounding the eyes and mouth can leave permanent dyschromic changes.
7. The utilization of hydrating and sunblocking lotions was effective in preventing permanent skin color changes.
8. The burning sensation felt after local anesthesia wears off following deep peeling procedures was well controlled with topical application of lidocaine jelly. Application of solid Vaseline for 24 hours thereafter, in combination with hydrating lotions, was also quite effective.
9. Facial edema, which may last up to 3 days, is expected after diffuse deep peeling of the face.
10. After deep peeling (physical or chemical) of the face, there is crust formation after the 3rd day. This persists until the 10th or 12th postoperative day.
11. Regular follow up visits are of utmost importance in order to keep best care during the period of erythema.

This period of persistent erythema should be discussed throughly during the first office visit.

12. Criteria for patient selection have to be rigorous and take into account patient ethnicity as well as previous medical history. The procedure is contra-indicated in patients who tend to form cheloid or hypertrophied scars.

13. Results with removing tattoos were not satisfactory. Rubilaser treatment, performed by skilled practitioners, still remains the procedure of choice.

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