

SKIN LESIONS INDUCED FROM THE RADIOSURGICAL UNIT AND VOLTAIC ARC DERMOABRASION: A RABBIT MODEL.

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The aim of this study was a histological evaluation of skin lesions induced from the radiosurgical unit and voltaic arc dermoabrasion: a rabbit model. Materials and methods: eight New Zealand male rabbits with a weight average 3.9 Kg, participated in this study. Dorsal part of each rabbit was shaven and divided in two equal parts of 5 cm. Voltaic arc dermoabrasion (Plexer, GMV s.r.l. Grottaferrata, Italy) in one side and radiosurgical unit (Laser elettronica Milano 1,75 MH) on the other were used to remove the keratinized layer. In each area were performed 10 sites of abrasion for a total of 20 sites per rabbit. The animals were sacrificed in groups of two at days: 0, 7, 14 and 21 with a Tanax overdose. The treated skin was removed using a scalpel and a block section containing the subcutaneous layer was effectuated. There were obtained 20 biopsies from each block section, 10 performed with el- bras and 10 with radiosurgical unit for a total of 40 biopsies per study time. **Results:** the present results demonstrated the possibility on containing the thermal damage of the lesions adjacent tissues using dermoabrasion. There were no observations of thermal damage on the underlying dermal tissue. Absent necrotic layer on the healing process was shown but an inflammatory infiltrate was present. The reduced thermal damage on the subcutaneous tissue is probably due to the current passage absence on the tissues. This is necessary to close the electric circuit between the active electrode and the neutral one in which the patient is part when using the radiosurgical unit. The arc voltaic dermoabrasion technique in comparison with the electroscalpel demonstrated the capability to contain the damage within the parenchyma.

Electrosurgery is the application of an alternative electric current with a high voltage on a biological tissue with a thermal effect to achieve an incision or coagulation. The effect is related to the electrode type, contact area, electrode movement speed and tissue characteristics. The cut is due to the current passage through active and neutral electrodes and the coagulation occurs as a result of tissue atrophy or desiccation when their heating is sufficiently slow. Parameters assessment to obtain the desired results may be done manually or automatic (1). The electrosurgery is not cauterisation as the thermal effect given is not external (e.g. caused by an elevated temperature tool) but internal, caused from the current passing within the tissue. William T. Bovie created the first electrosurgical unit

working at the Harvard University from 1914 since 1927; while the first surgical intervention was realized by Harvey Cushing at the 1° October of 1926. Different techniques have been used on the dermatological surgery to remove vascular lesions, dark patches and neformations. Laser, radiosurgical unit and dermoabrasion are widely uses and each of these technologies has its limits.

The laser is expensive and not always available in an aesthetic medicine operative unit. In order to remove all the lesions types, it would not be sufficient a single tool but 3-4 with different wave length.

It also supplies packs of energy which are totally adsorbed, so it has to be considered the damage on the nearest tissues, due to the light and heat diffusion

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produced (2), and it may cause damage if used improperly (3).

Meanwhile the radiosurgery unit is economic and ubiquitous in all aesthetic medicine operative units. It has an advantage on presenting interchangeable inserts and being modular on supplying variable energy for voltage, amperage and power.

The electrosurgery is one of the most soft tissues surgery used techniques, which may be ablate leaving a 100-400 μm necrotic tissue layer. It is a surgical technique that uses a high frequency (HF) electric current to realize a simple and easy cut or /and clot. So it is possible to have a precise cut and clotting at the same moment having a free blood operative field (4).

A throb wave with a variable frequency is used to coagulate the tissues. The electric current passing the tissue heats it and causes the evaporation and ionisation of the water contained on the tissue in contact with the electrode provoking its chipping or notch as a final effect. The tissue is heated under the evaporation limit but it can go through a denaturing process in function of the temperature reached; the latter is dependent on heat penetration depth and tissue thermal conductivity.

It is possible to minimize the thermal damage on the ablation zone nearest tissue. On the other hand the throb electric discharge of 100 μs duration gives deeper heat diffusion and a cut of 7 μm . The optimal discharge series during an electrosurgery is on the rate of hundred of microseconds.

Other consideration to be done is the radiofrequency, which follows the shortest electric path, the dehydrated tissues (discheratosic skin, superficial corneous layer, sebaceous excess, wrinkles callous borders, tattoo mottled pigmentation etc) behaves like insulation blocking the diathermic current to reach the bottom of the lesion. Also the free nervous termination depolarisation determines during the radiofrequency intervention an unpleasant sense of electric discharge, which necessitates frequently the anaesthesia.

The electrosurgical equipments do not take in consideration the different tissues conductibility. It is good conductors as vascular tissue or hydrated skin is easy to treat with electrosurgery. To handle this problems it is studied a voltaic arc dermoabrasion.

The voltaic arc acts without getting in tip-tissue contact, creating a gentle coagulation. There is no electric passage zone, for this reason the dermoabrasion it is not influenced from the tissue electric resistance. During operation it is important to be protected with masks to avoid viral particles inhalation (5).

The aim of this study is a histological evaluation of skin lesions induced from the radiosurgical unit and voltaic arc dermoabrasion: a rabbit model.

MATERIALS AND METHODS

This study was approved by the Ethical Committee for Human and Animal Studies at the School of Medicine, University of Chieti, Italy.

Eight New Zealand male rabbits, each weighting about 3.9 Kg were used in this study. The animals were anesthetized with a dose of Ketamine (Ketalar; Parke-Davis SpA, Milan Italy) and xylazine (Rompum; Bayer AG, Leverkusen, Germany). The ketamine was used at a dose of 44 mg/Kg and the xylazine to the dose of 6-8 mg/Kg for kilogram of weight. Dorsal part of each rabbit was shaven and divided in two equal parts of 5 cm. Voltaic arc dermoabrasion (fig.1)

(Plexer, GMV s.r.l. Grottaferrata, Italy) in one side and radiosurgical unit (Laser elettronica Milano 1,75 MH) on the other were used to remove the keratinized layer. A total of 20 sites per rabbit were performed. The postoperative course was uneventful. All rabbits were sacrificed in groups of two with a Tanax overdose at Days: 0, 7, 14 and 21. The area of interest of the treated skin was removed by means of a scalpel and a block section containing the subcutaneous layer was retrieved. There were obtained 20 biopsies from each block section, 10 performed with el- bras and 10 with radiosurgical unit for a total of 40 biopsies. A total of 160 sites were analysed, 80 with radiosurgical unit and 80 with voltaic arc microabrasion. The specimens were immediately fixed in 10% formalin and processed to obtain thin ground sections for histological analysis (Fig.2).

The slides obtained were stained with acid fuchsin and toluidine blue and then examined under a Leitz Laborlux microscope (Leitz, Wetzlar, Germania). Histomorphometry was performed using an AMD 1800 Mz PC, interfaced with a RGB(Matrix Vision GMbh) real colour digitalized video card, connected to a high resolution video camera (3CCD, JVC KY-F55B) and a software Image-Pro Plus 4.5 (Media Cybernetics Inc. Immagini & Computer Snc Milano, Italy). The images obtained were analyzed with the above software to calculate the percentage of inflammatory cells and the quantity of active fibroblasts.

Histological evaluation

Radiosurgical unit

T0

An in-homogeneous de epithelialisation of all the layers was observed microscopically.

The histological exam shown a complete skin de epithelialisation with basal layer removal and partial subcutaneous involvement area. The subcutaneous layer shown an inhomogeneous organization with morphological alterations due to the thermal damage (fig.3). A partial involvement of the follicular bulbs was also observed. The necrotic layer demonstrated a greater coloration due to the cytoplasmatic content leaking, no cells with nucleus were present. It represent the 20,1% of the analyzed tissue.

T7

There were shown necrotic cells and epithelial regenerations zones.

The follicular bulbs were surrounded by inflammatory cells with regeneration areas. The necrotic and inflammatory layer

represented 30,6% of the analyzed tissue.

T14

It was noted the appearance of the basal layer and a notable fibroblastic activity. It was also observed a neoangiogenesis with an inflammatory infiltrate which had an extension of 2 mm on the underneath subcutaneous layer. In some areas the epithelium was completely regenerated. The necrotic and inflammation layer represented 19,6% of all the analyzed tissue.

T21

There was observed a totally "restitutio ad integrum" of the epithelial layer.

A great vascularisation and a huge number of fibroblasts were noted on the sub epithelial area. There was no necrotic or inflammation area on the analyzed tissue.

Voltaic arc dermoabrasion

T0

A homogeneous depithelialisation of all the treated sites with bleeding areas were observed microscopically. There were no surgical sulcus induced by the equipment. Histologically a homogeneity on the de-epithelialisation was noted. The necrotic layer observed on the sites treated with radiosurgical unit was totally absent (fig.4).

There were no cells without nucleus and no altered coloration affinity observed. The necrotic layer represented 9% of the analyzed tissue.

T7

A light sub epithelial inflammatory infiltrate was present. The basal area was vital and the fibroblasts secrets connective matrix. An exfoliated keratin ascribable to the necrotic zone was shown. The necrotic and inflammation area represented 28% of all the analyzed tissue.

T14

The dermal layer was organized even it had inhomogeneous

thickness. This data could be probably due to the depth inhomogeneous treatment due to the operator sensitivity variable. The necrotic and inflammation area represented 9,8% of all the analyzed tissue.

T21

A complete "restitutio ad integrum" and reformation of all the skin layers was observed. It was also noted a huge number of vessels and fibroblasts secondary to the healing process. The necrotic and inflammation area was totally (score =0)

Statistical Valutation

From the necrosis/inflammation percentage evaluation was demonstrated that the necrosis and inflammation due to the voltaic arc dermoabrasion use were significantly reduced respect the one induced by the radiosurgical unit at T 0, 7 and 14 days ($P=0.001$), while there were no significant differences between the two at time 7 and 21 days ($P=0.032$).

DISCUSSION

The present results deduce the possibility on containing the tissue thermal damage contiguous the lesion using the voltaic arc dermoabrasion technique. There were no observations of thermal damage on the underneath treated site dermal layer. The necrotic layer is almost absent on the healing process, while it could be seen an inflammatory infiltrate.

This to our opinion is due to the tissue current path absence and to the necessity on closing the circuit between the active and neutral electrode to which the patient is part when used a radiosurgery unit. On the other hand,

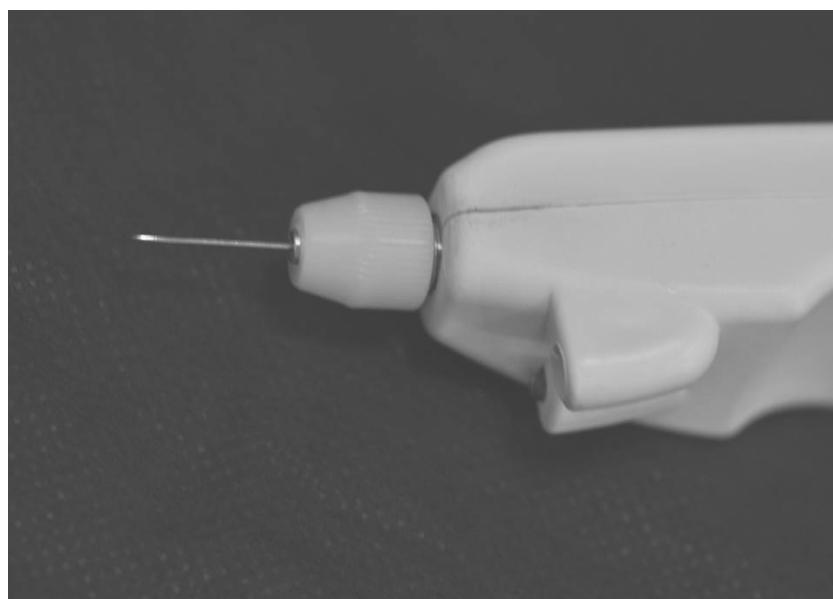


Fig.1. Voltaic arc dermoabrasion unit

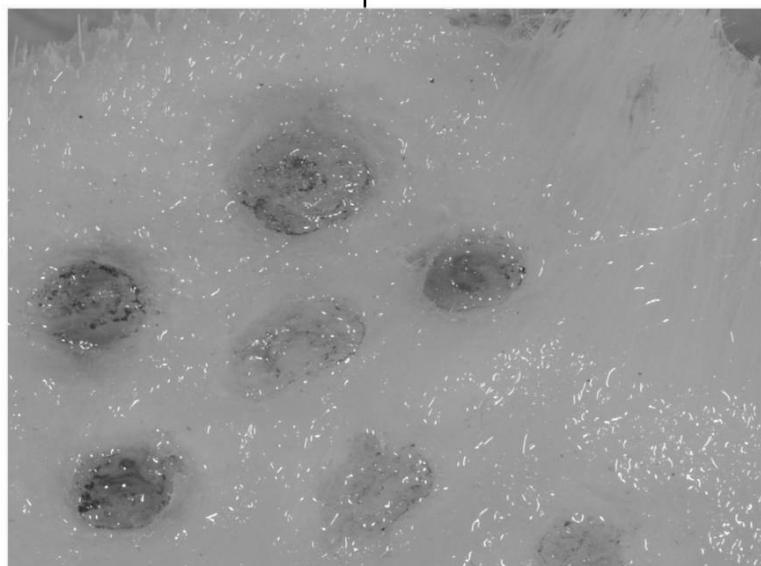


Fig.2. A block section containing the subcutaneous layer was retrieved

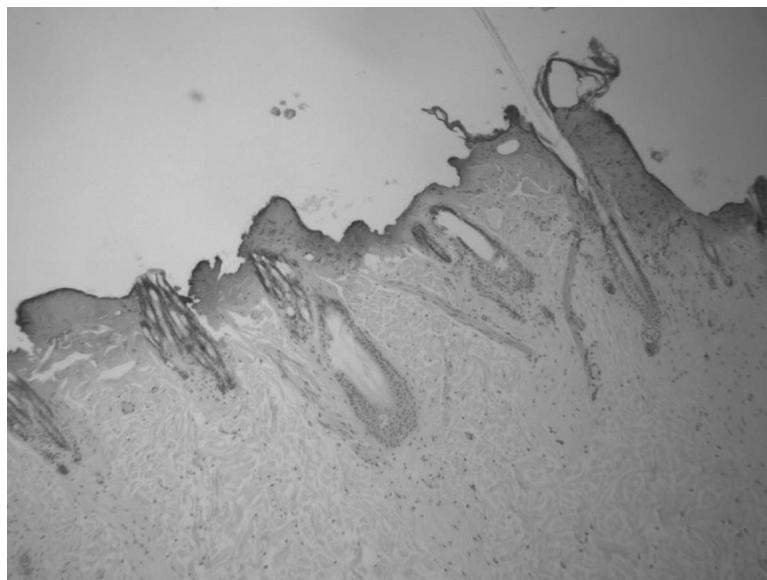


Fig.3. The subcutaneous layer shown a inhomogeneous organization with morphological alterations due to the thermal damage. The necrotic layer demonstrated a greater coloration due to the cytoplasmatic content leaking, no cells with nucleus were present. Acid fuchsin and toluidine blue 50 x

it may be concerning on patients with electric devices as pacemaker, orthopedic prostheses or arrhythmic patients (6). On the tissue treated by the radiosurgery unit were noted thermal necrosis on the underneath connective tissues and cellular disorganization which overstayed for 14 days. There was a difficulty on removing the skin on the initial phases, but when the tip of the radiosurgery unit arrived on the underneath sub epithelial layer its efficiency increased becoming faster. In this phase it is important to

keep the tip in contact with the tissue, but on the other hand it becomes difficult to control the cut depth cause of a better electric conductibility of the subcutaneous tissue. These results demonstrated how difficult is to effectuate a precise skin removal using radiosurgical unit, while it is possible to control the tissue removal depth using the voltaic arc dermoabrasion. This is due to the greater efficiency of the current induced on the connective tissue containing vessels and fluids rather than in the epithelial

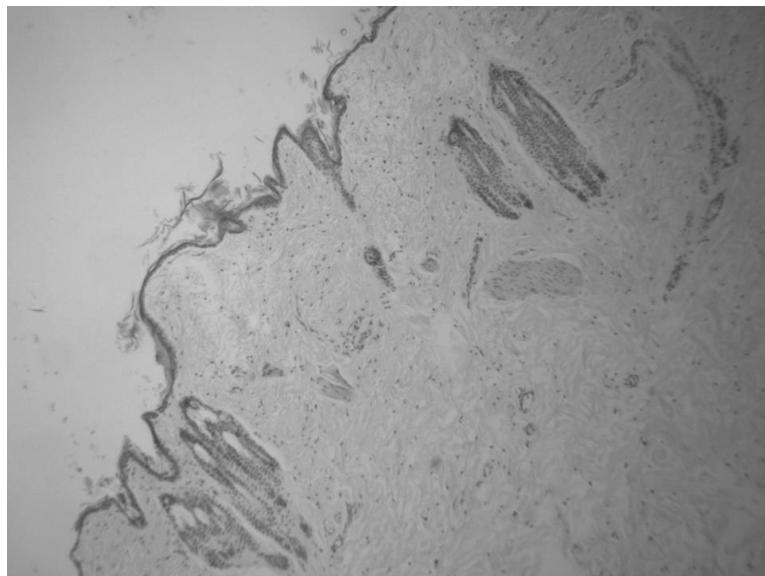


Fig.4. A homogeneous de epithelialisation of all the treated sites with bleeding areas were observed microscopically. Histologically a homogeneity on the de-epithelialisation was noted. The necrotic layer observed on the sites treated with radiosurgical unit was totally absent. Acid fuchsin and toluidine blue 50 x

tissue (4, 7). Voltaic arc dermoabrasion has the ability to burn selectively the conductive hydrated tissues (8). The electrons are substantially electric current, which can freely move through the human body without damaging it (low power), providing a hydrating (water, lymph or blood) contact point (skin) and being so a good conductor. This stream is irradiated from the dermoabrasion needle tip, which if finds a bed electricity conductor, tries to pass through and burns the fence. The spark created from the voltaic arc strikes without needle touching skin, and when it arrives on the healthy and irrorated part, it become inactive and terminates its destroying action. If the stream reaches an hydrated healthy tissue, passes it and enters on the body and irradiates without being detected. The dermoabrasion technique is inactive on the healthy tissues or damaged but hydrated, and active on damage but no conductor ones. This means that it could never create undesired damages even when it is used improperly.

With this technique is possible to make interventions on damage, no hydrated and no innervated soft tissues, without causing bleeding, pain (without anaesthesia), discolorations and hollows.

Use of the electric surgery has simplified the skin lesion treatment, making it a fast and complication free. The surgery has now new techniques in grade to guaranty the prevention of delicate structures. Nowadays the most used one is the electric energy given as monopolar or bipolar electrosurgery (7-9). Great part of the studies conducted to improve and innovate new

surgery techniques are effectuated on organs different form the cutaneous tissue. In addition the voltaic arc dermoabrasion is a new technique for this there is an absence of previous experimental or comparable studies. This study offers a basal research to obtain useful data regarding the clinical activity. It is quite notable that the scores obtained using the voltaic arc dermoabrasion are reduced compared to the one obtained with electrosurgery unit. This difference is statistically significant both in T0 and T15. This histological study permits to have available data regarding the healing process occurring immediately after the dermoabrasion.

The voltaic arc dermoabrasion demonstrated to have a capacity on containing the damage within the connective parenchyma making faster the tissue reparative process on all the studies times, both in the immediate damage and post operative reparative process evaluations.

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REFERENCES

1. Usatine R, Moy R, Tobinick E, Siegel D. Skin Surgery: A Practical Guide. St Louis: Mosby-Year Book; 1998.
2. Chapas AM, Brightman L, Sukal S, Hale E, Daniel D,

- Bernstein LJ, Geronemus RG. Successful treatment of acneiform scarring with CO₂ ablative fractional resurfacing. *Lasers Surg Med* 2008; 40:381-6.
3. Gruber EM, Tanzi EL, Alster TS. Side effects and complications of fractional laser photothermolysis: experience with 961 treatments. *Dermatol Surg* 2008; 34: 301-5; discussion 05-7.
 4. Hainer BL. Fundamentals of electrosurgery. *J Am Board Fam Pract* 1991; 4:419-26.
 5. Sawchuk WS, Weber PJ, Lowy DR, Dzubow LM. Infectious papillomavirus in the vapor of warts treated with carbon dioxide laser or electrocoagulation: detection and protection. *J Am Acad Dermatol* 1989; 21:41-9.
 6. O'Grady KF, Easty AC. Electrosurgery smoke: hazards and protection. *J Clin Eng* 1996; 21:149-55.
 7. Bouchier G. [The fundamentals of electro-surgery. High frequency current generators]. *Cah Prothese* 1980; 8:95-106.
 8. Karimipour DJ, Karimipour G, Orringer JS. Microdermabrasion: an evidence-based review. *Plast Reconstr Surg*; 125:372-7.
 9. Sebben JE. Cutaneous electrosurgery. Chicago: Year Book Medical Publishers; 1989.