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Review Article

Electrosurgery: Welcome Part of Modern Surgery

Neetu Aggarwal[1], Kapil Ahuja[2], Neha Pal[3], Rohit Pannu[4] ,Vikas Berwal[5],Neeraj[6]

[1] MDS (Oral and Maxillofacial Surgery), Goa Dental College and Hospital, Bambolim, Goa
[2,3] MDS Department Of Oral And Maxillofacial Surgery ,M.S.Ramaiah Dental College And Hospital
[4]MDS,Dept. of Conservative and Endodontics, Consultant, Bhiwani ,Haryana
[5,6] MDS,Department of Oral And maxillofacial Surgery, PGI Rohtak

ARTICLE INFO

ABSTRACT

Modern electrosurgery is a group of techniques by which high frequency alternating electrical current is applied to living tissues in order to achieve superficial coagulation, deep coagulation or cutting of the skin. Radiosurgery is the most advanced form of electrosurgery. The radiosurgical instrument uses a high frequency radio signal to perform a finer, less traumatic incision.It has numerous clinical applications in the dental practice, from performing precise surgical incisions to establishing hemostasis. When electrosurgery is applied according to principles, predictable and good wound healing can be achieved.

Keywords:
Electrosurgery, Radiosurgery, current

INTRODUCTION

Electrosurgery (ES) has been defined as the intentional passage of high-frequency waveforms or currents, through the tissues of the body to achieve a controllable surgical effect.[1]By varying the mode of application of this type of current, the clinician can use ES for cutting or coagulating soft tissues. Within the surgeon's armamentarium, electrosurgical devices stand out as some of the most useful and most used instruments. Modern electrosurgery units transfer current to the patient through cold electrodes.Radiosurgery is the most advanced form of electrosurgery. The radiosurgical instrument uses a high frequency radio signal to perform a finer, less traumatic incision.

HISTORICAL ASPECTS

Goldwyn described three eras encompassing the development of the modern electrosurgical technology. The first era began with the discovery and use of static electricity. The second era, best called "galvanization," evolved from Luigi Galvani's accidental discovery in 1786. His discovery and subsequent experiments led to the birth of electrophysiology. The third era, dating to 1831, was ushered in with discoveries by Faraday and Henry in England and America, respectively, who almost simultaneously showed that a moving magnet could induce an electrical current in wire.[2]

In 1881, Morton found that an oscillating current at a frequency of 100 kHz could pass through the human body without inducing pain, spasm or burn. In 1891,

* Corresponding author***: Dr.Rohit Pannu. H.No. 3037, New Housing Board, Sector – 13, Bhiwani (Haryana), India., E mail:rohitpannu87@gmail.com***

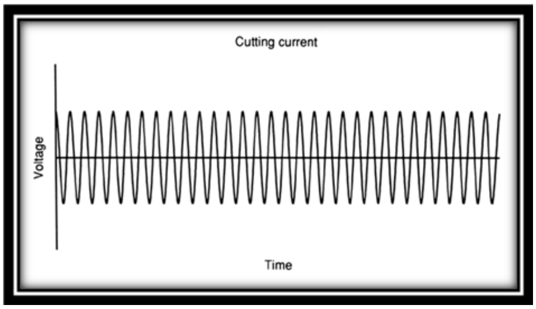

Figure 1. Cutting current: a pure sine wave.

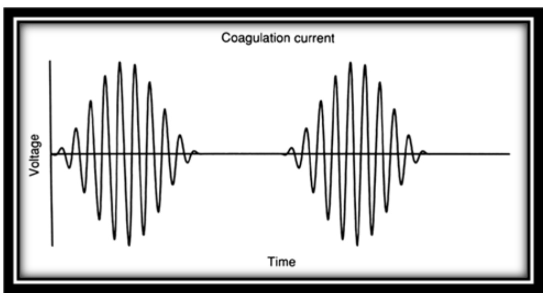

Figure 2:Coagulation current: intermittent bursts of high voltage current

d'Arsonval published similar findings with a frequencyloweredto10kHz. [3]

Around 1910, William Clark advanced the understanding of the electrical principles behind the electrosurgical apparatus used by Doyen and Nagelschmidt. Clark's alterations to the electrosurgical apparatus of the time essentially set the stage for the work of Bovie and Cushing, leading to development of an early version of the modern instrument used today.

Dr. Irving Ellman developed the fully filtered waveform combined with a frequency of 3.8 MHz, while Dr. Maurice Oringer wrote the first textbooks on the subject.[4]Extensive research of dental electrosurgery was conducted by Dr. Maurice J. Oringer. He is credited with being the 'father of dental electrosurgery. [5]

Dr. Goldstein coined the term “radiosurgery” to clearly describe the 3.8- to 4-MHz radio wave device.

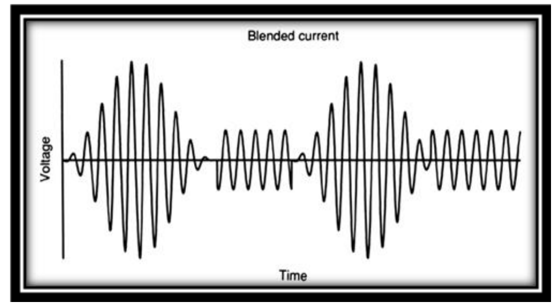

Figure 3. Blended current: A combination of cutting and coagulation currents

INDICATIONS OF ELECTROSURGERY IN ORAL AND MAXILLOFACIAL SURGERY

1. Impacted tooth exposure
2. Operculectomies
3. Orthodontic exposure
4. Removal of epulis fissuratum
5. Palatal stripping of hyperplastic palate (papillomatosis)
6. Tuberosity reduction
7. Enucleate fistulous tracts
8. Apicoectomies
9. Destruction of cyst remnants
10. Incision and drainage
11. Incisional and excisional biopsies
12. Removal of benign and malignant lesions
13. Implant flaps and exposure
14. Coagulation of soft tissue
15. Bipolar microcoagulation

Electrosurgery is a less invasive method to remove the dental implant. This involves the use of electrosurgery unit to cause a thermonecrosis of the bone and therefore a weakening of the bone-implant interface.[6]

Contraindications of Electrosurgery in Oral and Maxillofacial Surgery

By Patient:

- A pacemaker

- Metal plates, metal pins or metal prosthetic joints

By Lesion:

- Melanoma (electrosurgery is not indicated as a treatment modality)
- BCC- if sclerosing BCC or if larger than 2 cm

By location for malignant lesions:

- Body folds-alar groove and inner canthus of eye (higher chance of deep invasion of tumor)
- SCC on non-sun exposed skin and mucous membranes (more aggressive) [7]

ADVANTAGES

- Simple to use
- Easy to master
- Useful for a variety of skin lesions
- Rapid technique
- Controls bleeding while cutting or destroying tissue
- Equipment compact and affordable
- When used for tissue destruction sterile conditions or sutures are not needed
- Infections rarely develops in wounds left open [7]

DISADVANTAGES

- Safety risk (electric shock, burns or fires)
- Hypertrophic scars, especially with poor technique
- Risk of “channelling” of current down vessels and nerves
- Smoke may carry viral particles
- Delayed hemorrhage
- Unsightly wound
- Slow healing, especially if large area treated
- Obliteration of histology because of tissue destruction
- Electrosurgical artifacts at margins if used for biopsy [7]

BIOPHYSICS OF ELECTROSURGERY

Types of Currents

Electrosurgical generators are capable of producing a variety of current waveforms. Depending on the clinical results desired, different waveforms can be used to produce differing tissue effects.

Waveforms can be altered by the multiplication of two or more signals, a process called modulation. Damped and blended currents are examples of this process. There are three basic types of current waveforms used in electrosurgery: cutting current, coagulation current, and blended current.

Cutting Current: A continuous sinusoidal waveform cuts tissue with very little hemostasis. This waveform is simply called cut or pure cut. During each positive and negative swing of the sinusoidal waveform, a new discharge arc forms and disappears at essentially the same tissue location. The electric current concentrates at this tissue location, causing a sudden increase in temperature due to resistive heating. The rapid rise in temperature then vaporizes intracellular fluids, increases cell pressure, and ruptures the cell membrane, thereby parting the tissue. This chain of events is confined to the vicinity of the arc and the current density is no longer high enough to cause resistive heating damage (Figure 1).

Coagulation Current: Coagulation current is characterized by extensive wave modulation, which produces intermittent bursts of damped sine waves of high peak voltages (Figure 2). These peak voltages

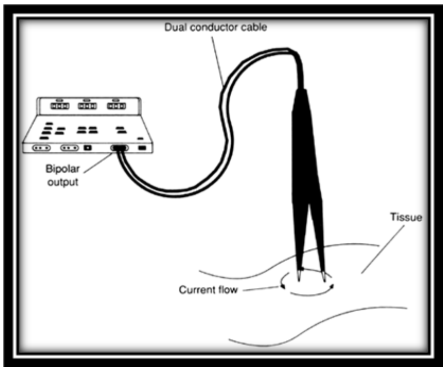

Figure 4. A bipolar circuit

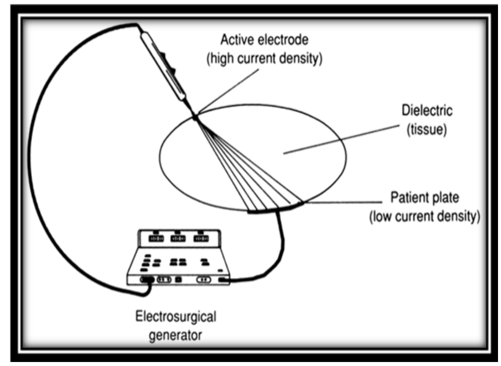

Figure 5. A unipolar circuit

thermal destruction, making this current particularly suited for the coagulation of bleeding vessels result in high tissue temperatures and hence significant.

maintaining a variable degree of hemostasis. Blended currents are created by modulating a second, lower frequency, higher amplitude sine wave with the sine wave from the cutting generator, producing a higher peak-to-peak voltage (Figure 3).

A second form of time varying current is produced by the process of rectification, in which an alternating current is modified so that it becomes unidirectional. This may be done by either blocking the portion of the wave with a negative polarity (half wave or partial rectification) or by reversing the negative portion of the wave (full wave rectification).

The Electrical Circuit: The type of circuit used in electrosurgery is termed a dipole circuit. A dipole circuit consists of two electrodes in contact with a dielectric or substance with limited electrical conductivity. In electrosurgery, human tissue is the dielectric. Two types of dipole circuits are possible: bipolar and unipolar.

Bipolar: In electrosurgery, a high current density is applied through bipolar forceps, coagulating the small amount of tissue contained between the tips of the forceps with minimal effect on surrounding tissue.

Both electrodes of the dipole are located at the site of coagulation (Figure 4).

Unipolar: In unipolar electrosurgery, a small active electrode relative to the patient plate is used at the site of surgery. The high current density produced at the active electrode creates a pronounced diathermic effect, causing tissue destruction at the operative site. The patient plate's large size lowers the current density at its placement site, preventing unwanted burns. The two electrodes and the patient's tissue form a circuit (Figure 5).[8]

PRINCIPLES OF RADIOSURGERY

Radiosurgery is the introduction of a high-frequency radio wave of 3.0-4.0 megahertz (MHz) above AM and below FM frequencies. The high-frequency radio signal produces a pressureless, micro smooth incision with hemostasis and minimum tissue alteration.

Radiosurgery offers the ability to perform as both a monopolar and bipolar instrument. In the monopolar mode, the incision is made with a fine tungsten wire. This mode is used to delicately remove or recontour tissue. The bipolar mode is used for precise, pinpoint coagulation during microsurgery.[5]

ELECTROSURGERY VERSUS OTHER THERAPEUTIC MODALITIES

Electrosurgery Vs Cryosurgery

Cryosurgery is often the treatment of choice for actinic keratoses and simple warts. It is faster and easier to

Figure 6. Electosurgical unit

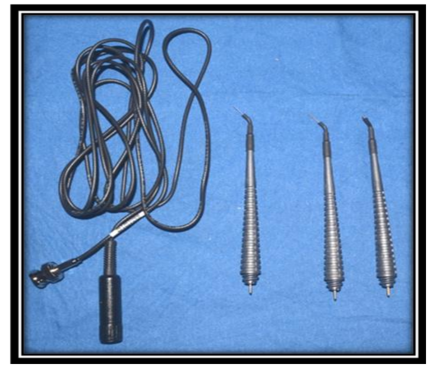

Figure 7. Sterilizable electrodes

perform than electrosurgery for these indications because it does not require anesthesia. Cryosurgery also tends to cause less scarring than electrosurgery for both of these lesions. However, cryosurgery may be more likely to cause hypopigmentation because the cold kills the melanocytes. Other disadvantage is that with cryosurgery the final result cannot be seen immediately. Cryosurgery also causes more postoperative swelling, but is only a transient phenomenon.[7]

Electrosurgery Vs Scalpel

Scalpel is inexpensive, the blades are disposable and the cuts are clean. The scalpel causes no heat-induced tissue damage that could obscure the pathology specimen. Using electrosurgery in place of the scalpel has the advantage of facilitating hemostasis while cutting. However, the lateral heat produced by the electrosurgical instrument can cause tissue damage that might cause slow healing and artifact on the edges of the biopsy specimen. [9]

Electrosurgery Vs Laser

Electrosurgery is less expensive than laser surgery. The standard electrosurgical units are a fraction of the cost of a laser. The high cost of the laser is the determining factor in the cost of the treatment. As with electrosurgery, the CO_2 laser may be used to cut, coagulate, and destroy tissue. The pulsed dye laser or a similar yellow light laser is unequivocally better than electrosurgery for treating large hemangiomas and maximizing the cosmetic result. There is much less chance of scarring. Electrosurgery can also achieve good results when certain variables such as waveform, power, speed of instrument movement and depth of tissue coagulation are properly selected and controlled.[7]

ELECTROSURGICAL EQUIPMENTS

An electrosurgical unit (Figure 6, 7) passes high-frequency electric currents through biologic tissues to achieve specific surgical effects such as cutting, coagulation, or desiccation. The surgeon selects either one of these waveforms or a blend of them to suit the surgical needs.

Sterilization of Electrosurgical Probes: Contrary to what was previously believed electrosurgical electrodes are not self sterilizing. Recent recommendations are for the use of disposable electrodes. This is quite expensive so a more economical alternative is to sterilize the electrodes with gluteraldehyde or another suitable method of sterilization like ethylene oxide gas.[10]

VARIABLES AFFECTING ELECTROSURGERY PERFORMANCE

Reversible changes occur in tissue when tissue temperature reaches 37-45 ^{0}C while doing electrosurgery. Beyond 45 ^{0}C coagulation of the protein contents of cell occurs, which is irreversible state. When tissue temperature rises above 60 ^{0}C, water content of the cell is driven out. Beyond this desiccation temperature, heat causes disintegration of cellular components into oxygen, nitrogen, hydrogen and other elements including carbon.[11]

Lateral heat: When the active electrode tip contacts the tissue the intense heat causes disruption of cells at the line of incision and/or coagulation, some of it also spreads to the adjacent cell layers. This heat is called the lateral heat. Lateral heat causes coagulation necrosis on the cell layers adjacent to all incision sites. Therefore, when ES is performed, the main objective is to produce a clean incision and / or coagulation with minimal lateral heat.

Size and type of active electrodes: The thicker the electrode, the greater the amount of lateral heat.

Wave form: The choice of waveform depends on (1) the required Surgical effect, i.e., whether tissue separation or hemostasis is required and (2) the proximity of bone to the surgical site. The fully rectified waveform produces excellent tissue separation with the least amount of lateral heat, but it also produces very little hemostasis. The fully rectified, unfiltered waveform produces good tissue separation with effective hemostasis. The partially rectified waveform produces much more lateral heat than the fully rectified, unfiltered waveform therefore it can be used only for the control of hemorrhage in soft tissue.

Cutting time: The quicker the active electrode is passed over the tissue, the lesser the lateral heat. The active electrode must not remain in contact with tissue for more than 1 to 2 seconds at a time and successive applications of the electrode on the same spot must have a 10 to15 seconds interval. This interval allows the heat produced on the wound to dissipate and prevents overheating of the tissue surface before the next application of the electrode.

Surface tissue condition: The surface of the tissue must be moist to allow heat dispersal.

Clinical Guidelines Based Up on Research Reports

(1) Incision of intraoral tissues with electrosurgery should be accomplished with a higher frequency unit tuned to optimal power output and set to generate a fully rectified-filtered waveform.

(2) The smallest possible electrode should be selected to accomplish the incision.

(3) Electrosurgical incisions should be made at a minimum rate of 7 mm/ s.

(4) A cooling period of 8 s should be allowed between successive incisions with a needle electrode at the same surgical site. The period must be increased to fifteen seconds when a loop electrode is utilized for excisional procedures.

(5) The clinician should anticipate a slight amount of gingival recession when an electrosurgical incision is used for troughing or excision of the gingival crevice.

(6) Contact of the activated electrosurgery electrode to the cemental surface of a tooth must be avoided in regions where connective tissue reattachment is desired.

(7) Intermittent contact of an active electrode delivering a well-controlled current to alveolar bone will initiate only slight osseous remodelling which will not result in clinical changes. Incorrect current control or extended contact with alveolar bone may produce irreversible changes capable of resulting in diminished periodontal support.

(8) Contact of an active electrosurgery electrode with metallic restorations should be limited to periods less than 0.4 s. Longer periods of contact may result in pulpal necrosis.

(9) Electrosurgery may be used effectively for pulpotomy procedures.

(10) Use of electrosurgery to provide fulgurating sparks for use in obtaining hemorrhage control should be used

only after all other clinical methods have been tried, A delayed healing response following the use of fulguration should be expected.

(11) Electrosurgery may be used safely and conveniently to excise inflammatory papillary hyperplasia.[12, 13]

SAFETY MEASURES WITH ELECROSURGERY

Potential Hazards of Electrosurgery (To Patient and Physician):

- Fire and burns
- Electric shock
- Transmission of infection through electrode, smoke plume, or spattering blood
- Pacemaker problems

Safety Precautions to Avoid Potential Hazards:

Fire and burns

- Do not use alcohol to prepare the skin
- Do not use ethyl chloride as local anesthetic
- Keep oxygen and other flammable material away from electrosurgical equipment
- Have fire extinguisher available
- Be careful of bowel gas in perirectal procedures

Electric shock

- Keep electrosurgical equipment functioning properly; if there are signs of malfunction, get equipment fixed before use
- Use three-pronged plug connected to an outlet that is not overloaded
- Do not use the outlet in the treatment table
- Do not make or break contact with patient while the electrode is activated
- Make sure patient is not grasping or touching metal portions of the treatment table

Transmission of infection through electrode

- Always wear gloves
- Use disposable electrodes when possible
- Use disposable, metal-hubbed needles with an adapter.
- When using reusable electrodes, clean them after each use by removing the char and sterilizing the electrodes.
- For small procedures, in which minimal electrosurgery is needed, an assistant who is not part of the sterile field can apply the electrosurgery as needed.

Transmission of infection through smoke plume or spattering blood

1. Use a smoke evacuator with the intake nozzle held within 2 cm of the operative area.
2. The physician and treatment team should wear surgical masks and eye protection
3. Consider using a different treatment modality based on evaluation of the risks and benefits of treatment.

Pacemaker problems

Electrosurgery should be avoided in patients with pacemakers (or cardiac monitoring equipment). Thermal pencil cautery is not contraindicated in patients with pacemakers.[10]

POSTOPERATIVE INSTRUCTIONS

- The patient should avoid smoking, eating of hard or spicy foods, citrus juices and alcohol following surgery.
- Following electrosurgery, it is normal to experience some discomfort; therefore analgesics can be prescribed.
- To control swelling areas of extensive surgery,the patient should be instructed to apply ice packs to the area.
- Patients should be instructed to call if any problem arise.
- Post-operative application of an antibiotic ointment is a good practice. This or petroleum jelly should be continued for 5-7 days since wounds heal best in a moist environment.

- Sunscreen use is a must for photoexposed areas like the face to minimize post- inflammatory erythema and hyperpigmentation. [10, 14]

COMPLICATIONS

1. Complications related to poor operative technique and include gouging of tissue, deep cuts and burns.
2. Bleeding which can be minimized with appropriate current setting but small arterioles can sometimes be nicked and this requires pressure packing for 10 minutes.
3. Secondary infections can occur either during or after the procedure.
4. Pain is common for 1-2 days after electrosurgery but this is usually mild and can be managed with nonsteroidal anti-inflammatory drugs. [10]

RECENT ADVANCES

Active Electrode Monitoring Systems

In an effort to minimize the risks of insulation failure and capacitive coupling, active electrode monitoring systems now exist. When interfaced with electrosurgical units, these systems continuously monitor and shield against the occurrence of stray electrosurgical currents.[11]

Tissue Response Generator

Tissue response generators are the next step in the evolution of electrosurgical generators. These generators adjust automatically responding to tissue changes maintaining power delivery and minimizing drag. [11]

Vessel Sealing Technology

The most recent advancement in electrosurgery has been the introduction of vessel sealing technology. Core to this technology is the use of bipolar electrosurgery that relies on tissue response generators. This advanced electrical current is combined with optimal mechanical pressure delivery by the instruments to fuse vessel walls and create a seal. [11]

Electrosurgery with addition of argon gas

Electrosurgery is being enhanced by the addition of a controlled column of argon gas in the path between the active electrode and the tissue. The flow of argon gas assists in clearing the surgical site of fluid and improves visibility.

Many manufacturers have begun to include sophisticated computer-based systems in their ESUs that not only simplify the use of the device but also increase the safety of patient and operator. For instance, in a so-called soft coagulation mode, a special circuit continuously monitors the current between the active electrode and the tissue and turns the ESU output on only after the active electrode has contacted the tissue. Furthermore, the ESU output is turned off automatically, once the current has reached a certain threshold level that is typical for coagulated and desiccated tissue. This feature is also used in a bipolar mode termed autobipolar. [15]

CONCLUSION

Mastery of electrosurgery remains a fundamental skill of the accomplished surgeon. This skill requires complete understanding of the biophysical aspects of the interaction of electrosurgical energy and tissue. Continued research into the area of tissue interaction shows promise in the potential development of novel applications of electrosurgery. Increased computing power, more sophisticated evaluation of voltage and current waveforms and the addition of miniaturized sensors will continue to make ESUs more user-friendly and safer.

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