Electrosurgery has been used in dentistry for several decades, but the technique is not widely practiced. This article briefly explains the principles of electrosurgery and attempts to clear up some misunderstandings about the healing of electrosurgical wounds. Clinical application of electrosurgery for the management of some common oral conditions is also described. (Quintessence Int 1998;29:649–654)

Key words: current, electrosurgery, waveform, wound healing

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. By varying the mode of application of this type of current, the clinician can use ES for cutting or coagulating soft tissues. Tissues are naturally resistant to high-frequency waveforms; when these waveforms pass through it, intense intracellular heat is produced within the tissues contacted by the active electrode tip. This heat volatilizes cells, and as the electrode is guided through the tissue, it leaves a path of cell destruction in the form of an incision or surface coagulation.

Electrosurgery was introduced to dentistry more than 50 years ago, but, although it can be used in almost all dental specialties, it is not widely used. Since the introduction of lasers in dentistry, use of ES has further declined. This decline may be due to the fact that ES is not taught in most dental schools, and the presence of some conflicting reports on the healing of electrosurgical wounds may deter some dentists from using ES. The purpose of this article is to make ES more familiar and acceptable to dentists by (1) briefly explaining the principles of ES, (2) presenting some of its many clinical applications, (3) outlining its advantages and disadvantages, and (4) clearing up some misunderstandings about the healing of electrosurgical wounds.

Electrosurgery unit

The ES unit consists of four components:

1. The current generator produces the high-frequency waveforms, which range from 1 to 4 MHz. The higher frequencies are better because they produce less lateral heat. The power output of ES units ranges from 70 to 100 W.
2. The active electrode is the one through which the high-frequency waveforms enter the tissue being operated. A wide range of active electrodes are available, but all of them basically belong to one of three types of electrode: Single-wire electrodes are used for incision or excision; loop electrodes are used for tissue planing; and heavy, bulkier ball electrodes are used for coagulation.
3. The passive electrode (ground plate) is a flat plate that has a broad, indirect contact with the patient’s body. Like an antenna, it receives the waveform that has entered the patient’s body and allows it to return to the unit.
4. The on-off switch activates or deactivates the ES unit. This can be operated by a foot control or by a switch on the handpiece. The foot control is preferred because the operator will usually find it difficult to control the switch and the cutting stroke at the same time with the same hand.
### TABLE 1 Properties of electrosurgery waveforms

<table>
<thead>
<tr>
<th>Property</th>
<th>Fully rectified &amp; filtered</th>
<th>Fully rectified &amp; unfiltered</th>
<th>Partially rectified</th>
<th>Fulguration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow character</td>
<td>Continuous</td>
<td>Pulsating</td>
<td>Intermittent</td>
<td>Half-wave modulated</td>
</tr>
<tr>
<td>Application</td>
<td>Cutting only</td>
<td>Cutting with coagulation</td>
<td>Coagulation only</td>
<td>Superficial carbonization</td>
</tr>
<tr>
<td>Efficiency of cutting</td>
<td>Very good</td>
<td>Good</td>
<td>Poor</td>
<td>None</td>
</tr>
<tr>
<td>Efficiency of coagulation</td>
<td>Minimal</td>
<td>Good</td>
<td>Very good</td>
<td>Excellent</td>
</tr>
<tr>
<td>Production of lateral heat</td>
<td>Minimal</td>
<td>Little</td>
<td>A lot more</td>
<td>Greatest</td>
</tr>
<tr>
<td>Tissue shrinkage</td>
<td>Minimal</td>
<td>Little</td>
<td>A lot more</td>
<td>Greatest</td>
</tr>
</tbody>
</table>

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**Lateral heat**

When the active electrode tip contacts the tissue, the electrode itself does not produce any significant heat; rather the intense heat that is required for the electrosurgical effect is generated within the tissues that are contacted by the electrode tip. While this intracellular 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. However, this necrosis is minimal, and any unwanted tissue destruction is caused by excess lateral heat. Therefore, when ES is performed, the main objective is to produce a clean incision or/and coagulation with minimal lateral heat. This objective can be achieved by controlling several factors.²

**Size and type of active electrodes**

Many types of electrode are available, and the thicker the electrode, the greater the amount of lateral heat. The width of necrosis that occurs on the site of ES varies according to the type of active electrode that has been used. In a study of electrosurgical wounds, it was reported that the needle-type electrode, which is used for incisions, creates a 0.12-mm-wide necrosis, and the loop electrode, used for tissue planing, makes a 0.31-mm-wide necrosis.³ The same report also concluded that large electrodes cause more tissue damage than small ones.³

**Power setting**

When the power setting is not sufficient, there is tissue drag and adherence of small bits of tissue to the electrode tip. A high-power setting causes sparking and charring of the surface tissue. The optimum power setting, which is between these two extremes, can be set only after the operator gains some experience by trial and error.² Thicker electrodes require a higher power setting, which in turn will produce increased lateral heat.

**Waveform**

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 (Table 1).

**Cutting time**

The quicker the active electrode is passed over the tissue, the lesser the lateral heat. It has been estimated that to generate an effective incision, while keeping the lateral heat at a minimum level, the electrode must be guided over the tissue at a speed of 7 mm/s.⁴ 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- to 15-second interval.⁵ 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. Because thicker electrodes produce more lateral heat, the interval between the strokes has to be increased according to the electrode thickness.
Surface tissue condition

The surface of the tissue must be moist to allow heat dispersal. A dehydrated tissue surface causes sparking, tissue drag, and delayed healing. Therefore, it is desirable for the tissue surface to be wetted with the patient’s own saliva or water or saline. Irrigation of the surgical site immediately after ES will also help to minimize lateral heat.

Electrosurgery waveforms and their applications

A wide variety of ES units, with varying power, frequency, and waveform options, are available. Depending on the model, an ES unit can produce up to four different waveforms. For a beginner, choosing the appropriate waveform for a particular procedure is the biggest problem, and success of the ES technique may depend on this choice.

Fully rectified, filtered waveform

This is a pure, continuously flowing current that permits a very smooth incision. Because this waveform produces the least lateral heat and minimal surface coagulation, the incision made by this current closely resembles a scalpel incision. The wound also heals with very little tissue shrinkage.

This waveform can be used for all soft tissue surgeries, such as frenectomy, incision and drainage, and gingival troughing procedures around the anterior teeth. Because only one cell layer is damaged when this waveform is used, even a biopsy procedure (Figs 1a to 1c) can be performed without loss of tissue architecture. Procedures that involve incision of the periosteum can also be safely carried out if prolonged contact with the underlying bone is avoided.

Fully rectified, unfiltered waveform

This is a pulsating current that has slightly less cutting efficiency. In addition to a smooth incision, this waveform produces superficial coagulation, leading to effective hemostasis. This waveform causes tissue shrinkage and additional lateral heat; therefore, it cannot be used on tissues that are in close proximity to bone.

It is suitable for most minor oral surgery procedures, including gingivectomy (Figs 2a to 2c), gingivoplasty, pulpotomy, tissue removal for exposing cervical caries, excision of hyperplastic soft tissues, and gingival sulcus troughing for the posterior teeth.

Partially rectified waveform

This is an intermittently flowing, high-frequency current, which is excellent for producing hemostasis but inefficient for incising soft tissues. Because it produces a great amount of lateral heat, use of this waveform near bone must be avoided. Inflamed soft tissue can be excised with a fully rectified waveform, and the hemorrhage can be controlled by the partially rectified waveform (Figs 3a and 3b).

Endodontically treated and discolored teeth can be bleached by the thermocatalytic technique, in which heat is utilized to release oxygen from a hydrogen peroxide solution, which is the bleaching agent. The heat source is the ES current. However, this technique is indicated only for resistant stains that fail to respond to other bleaching techniques.

Inadvertent contact of the ES electrode with the tooth and the resulting lateral heat has been reported to cause some damage to the periodontal apparatus, and this may lead to cervical resorption. However, precautions taken to prevent overheating of the periodontium may prevent this effect. This is done by isolating the tooth...
Fig 2a Hyperplastic gingiva is present in a patient undergoing orthodontic treatment.

Fig 2b The hyperplastic tissue has been excised and the gingiva has been planed to produce contours ideal to esthetics and oral hygiene practice.

Fig 2c Complete healing is apparent 1 month after gingivectomy.

Fig 3a The gingiva is inflamed and hyperplastic.

Fig 3b The gingival enlargement has been excised with a fully rectified waveform. However, if bleeding is excessive, a partially rectified waveform can be used to produce surface coagulation with rubber dam and limiting every electrode application to no longer than 1 second with a 5-second interval between each application. The tooth is also irrigated after every electrode application.

**Fulguration waveform**

This is a half-wave modulated current, also called the sparking current. The spark occurs as a result of a high-voltage surge of power when the partially rectified current is used in a moneterminal circuit, ie, without the passive electrode. Because of the absence of the passive electrode, the current escapes from the patient in all directions (and therefore the results are erratic). This current produces the greatest amount of lateral heat. But it can be used on soft tissue near bone because the electrode tip is always kept about 0.5 mm away from the surface of the tissue.

When activated, the initial surge of current produces a spark that passes from the electrode tip to the tissue, causing superficial destruction by carbonizing the tissue surface. This sparking current is ideal for the destruction and removal of remnants of cysts following their enucleation. Because the clinical application for this waveform is very limited, fulguration capacity is available only in some ES units. This waveform should be used only by a person experienced in electrosurgery.

**Wound healing in electrosurgery**

The histologic effect of ES varies, depending on the power output and frequency of the ES unit, the waveform selected, and the size and shape of the active electrode. Histologic analysis of ES wounds showed that ES units with the lowest frequency produce significantly greater tissue alteration than do ES units with higher frequencies. In a comparative study of electro-
surgical and scalpel wounds, it was observed that healing of electrosurgical wounds was delayed. Electro-surgical wounds had more inflammatory response and more tissue destruction. But in both kinds of wound the viability of osteoblasts was the same, and there was no increase in the osteoclasts, which would indicate that no bone resorption had occurred.

Comparing electrosurgery and periodontal knives, Glickman and Imber found that there was no difference in wound healing when the gingival resection was shallow. In deep resections, however, they found intense inflammation and loss of bone height resulting from bone necrosis. Gingival recession, loss of crestal bone height, and coagulation necrosis of the pulp have also been reported.

If only the preceding reports are taken into account, then ES has no place in dentistry. However, many other reports have shown that there is no difference in the healing of wounds produced by ES, scalpel, blade-loop knife, or retraction cords. Another study showed that, although there is loss of tissue soon after ES, 70% to 100% of the lost tissue is regained over a period of months. When teeth with cervical amalgam restorations were contacted by the active electrode tip to simulate clinical application, it was found that, contrary to an earlier report, there was no evidence of extensive damage or necrosis of pulp. It has also been shown that electrosurgical pulpotomy on primary molars has a success rate significantly better than that of formocresol pulpotomy.

In a review on healing of electrosurgical wounds, Williams has shown that many of the reports on electrosurgical wound healing have not mentioned the type of ES unit, the waveform, the size and shape of the electrode used, nor the speed at which the electrodes were passed over the tissue. Therefore, it is not possible to know whether some of the delayed wound healing reported was the result of the operators’ not having an optimal control of the factors involved in ES or whether ES is actually as damaging as it has been portrayed. Regular users of ES know, from experience, that when ES is applied according to principles, predictable and good wound healing can be achieved.

**Discussion**

Electrosurgery has several applications in almost all branches of dentistry, but this technique is not very widely used. The presence of conflicting and sometimes confusing information on electrosurgical wound healing in the dental literature is the most likely reason. Although some reports have focused on the negative aspects of ES, there are as many reports that have shown that there is no difference in the clinical healing of ES and scalpel wounds.

The inconsistency of reports on the healing of electrosurgical wounds may be attributed to the lack of standardization of the factors involved in ES. Just as preparation of a tooth with a high-speed turbine without adequate cooling spray can devitalize the pulp, use of ES without optimal control of the relevant factors can produce adverse effects. The factors to be controlled during ES are waveform, power setting, cutting stroke, and surface condition of the tissue. The thickness and shape of the active electrodes and the depth of the incision are other factors that can also affect outcome. When those factors are controlled, no clinical or significant histologic difference can be seen between the healing of electrosurgical wounds and that of scalpel wounds.

**Advantages of electrosurgery**

1. Tissue separation is clean, with little or no bleeding.
2. A clear view of the surgical site is provided.
3. Planing of soft tissue is possible.
4. Access to difficult-to-reach areas is increased.
5. Healing discomfort and scar formation are minimal.
6. Chair time and operator fatigue are reduced.
7. The technique is pressureless and precise.

**Disadvantages of electrosurgery**

1. The initial cost of the ES equipment is far greater than the cost of a scalpel.
2. The odor of burning tissue is present if high-volume suction is not used.
3. Although ES units are compatible with most modern pacemakers of today, it cannot be used on patients with older pacemakers that are not shielded against external interference.
4. Electrosurgery units cannot be used near inflammatory gases.

**Conclusion**

Electrosurgery can never completely replace the scalpel, but although ES requires more know-how and skill, its advantages outnumber and outweigh its disadvantages. An ES unit costs only a small fraction of the price of a CO₂ laser unit and can be used to perform many of the soft tissue surgical procedures being carried out with lasers. If the clinician practices ES techniques in the laboratory and applies them clinically according to the principles, he or she will surely find ES to be of immense use in clinical dentistry.
References


