4.0 MHz Radiowave Surgery in Cosmetic Facial Surgery

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INTRODUCTION

There have been many changes in the field of cosmetic surgery. An interesting statistic is that the average recuperating time for a face lift 20 years ago was 4.4 days in hospital.[1] Today, most facelift surgeries are outpatient procedures. One reason for this is that procedures have become more simplified due to advances in anesthesia, technology and healthcare. Of the technological advances, 4.0 MHz radiowave surgery is a modality worth investigating.

All surgeons are familiar with and have operated electrosurgery or Bovie machines. For the rest of this paper it is important to realize that radiowave surgery is vastly different from conventional electrosurgery. Both of these modalities receive power from standard 60 cycle AC current. This, however, is where the commonality stops. 4.0 MHz radiowave surgery represents new technology and is patented by the Ellman International Company in Oceanside, New York, USA.

Viewing the position of the devices on the electromagnetic spectrum in part explains that the higher the Mhz generated, the lower the lateral tissue damage. 4.0 MHz radiowave surgery sits on the electromagnetic spectrum between AM and FM radio signals (figure 1).

HISTORICAL PERSPECTIVE

Radiowave surgery has been shown to be an improved modality in soft tissue surgery.[2-8] The use of electricity for surgical incision and coagulation dates back to its inception. In order for alternating current to be used for surgery, a generator was required that could produce the

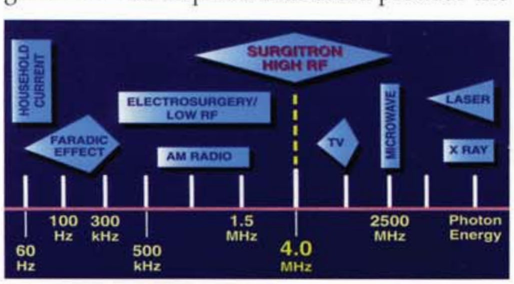

Figure 1 shows the position of 4.0 MHz radiowave surgery in the electromagnetic spectrum.

high-frequency current. This was developed in 1889 by Thompson, who noted heat in his wrists when immersed in saline solution while passing a current through his hands.[9] In 1891, d'Arsonval showed that electric currents with frequencies of greater than 10,000Hz failed to cause neuromuscular stimulation and the associated tetanus response.[10, 11] Oudin, modified d'Arsonval's equipment in the 1890s to generate a spray of sparks that caused superficial tissue destruction.[12] Work continued at refining the use of electrical current and in the late 1890s and early 1900s the use of electrodes was conceived to concentrate the density of the current. This enabled control of the spark and was successfully used to treat lesions and reported in 1900.[13] In 1907, de Keating-Hart and Pozzi introduced the term fulguration (from the Latin fulgur, meaning lightning). This referred to the superficial carbonization resulting from the spark from an Oudin coil when used to treat skin.[12] In 1909 Doyen introduced the term electrocoagulation (from the Latin word coagulare, meaning to curdle).[14] This was used to describe the tissue response when touched by an electrode while an indifferent electrode (antenna) was attached to the patient. The indifferent electrode allowed for the removal of the current entering the patient and channeled the electricity back into the electrosurgical unit. This prevented the build up of static electricity so electrical shocks were not caused to the patient or the operator. This recycling of current allowed the use of lower voltages with increased amperages and along with the bi-terminal electrode arrangement allowed for deeper tissue coagulation as compared to previous surface carbonization.[12] This circuitry set the stage for the device configurations utilized today. In 1923 Wyeth used electrosurgery for actually cutting tissues instead of merely charring or desiccating them. He developed an apparatus called the endotherm knife[15] that not only cut, but also sealed off smaller blood and lymphatic vessels. William Bovie, a Harvard physicist, developed a practical electrosurgical device in 1928 that offered both cutting and coagulation modes[16] which led to the modern machines used in today's hospital operating rooms.

There are significant differences between lower frequency electrosurgery and 4.0 MHz radiowave surgery in both the mechanisms and tissue response. Figure 2 shows the position of three common electrosurgical frequencies on the electromagnetic spectrum. Figures 3 and 4 show the lateral tissue damage zone between 360 KHz, 1.7 MHz, and 4.0 MHz frequencies. These images show the char on the periphery of a straight line incision. Figure 4 shows an enlarged view illustrating that the degree of lateral tissue carbonization decreases as frequency increases. This means that 4.0 MHz frequencies produce the least amount of lateral tissue damage. Again, this translates into faster healing with less swelling, bruising, discomfort and postoperative pain.

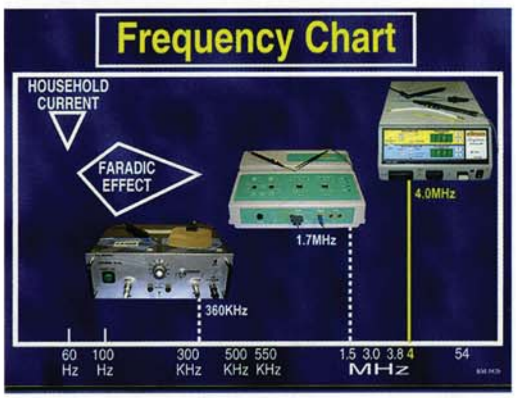

Figure 2. Three different common electrosurgical frequencies and their respective position on the electromagnetic scale.

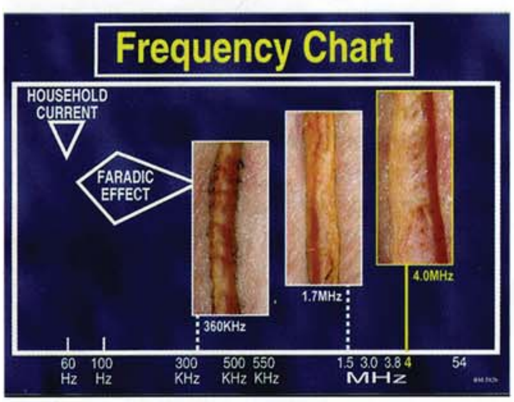

Figure 3. The amount of lateral tissue carbonization at various frequencies.

Common electrosurgery works by channeling electricity to the active electrode (cutting tip) and requires a bare metallic ground plate to be in contact with the patient's skin. It is the cutting electrode (tip) that provides the

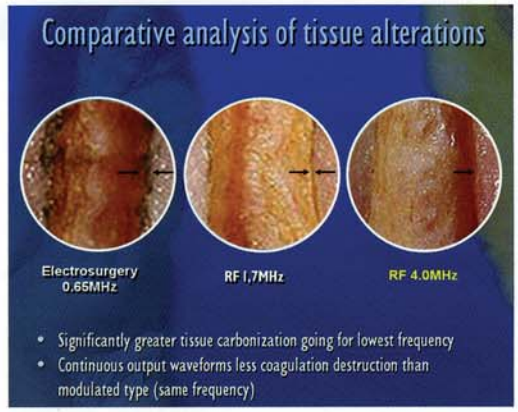

Figure 4. An enlargement showing the decrease of lateral tissue damage with increasing frequency.

electrical resistance for common electrosurgery. This means that the tip becomes hot (sometimes red hot) and in simple terms is merely a sophisticated soldering iron. Most of us have seen an electrode tip melt from excessive heat. Although electrosurgery is effective for incision and coagulation it is problematic due to the significant lateral tissue damage generated when incising and coagulating.

Radiowave surgery, on the other hand, functions quite differently. First and most importantly the active electrode (cutting tip) does not provide the resistance with radiowave surgery. This means that the cutting tip does not become heated. With radiowave surgery it is the tissue that provides the resistance and the cutting tip does not become heated. The simplified scheme of operation is that the current is channeled into the radiowave surgery unit and converted to multiple waveforms. As this radiowave energy leaves the cutting tip and conducts to the tissue, it causes the intracellular water to boil and volatilize. This process is referred to as intracellular volatilization. As the radiowave energy leaves the electrode tip and is transmitted through the tissues it is picked up by a neutral antenna (ground plate) and returned to the machine. The ground plate used with 4.0 Mhz radiowave surgery is very different from the metal ground plate used with conventional electrosurgery. Foremost in this system is the fact that the ground plate (neutral antenna) is covered with Teflon and no bare metal ever touches the patient (Figure 5).

Consequently, there is no danger of shock or burn to the surgeon or patient from the grounding plate. The ground plate merely functions as an antenna (much like a cell

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phone antenna) to attract the released energy to return to the machine. Since the antenna functions in this manner it is more efficient when placed as close as possible to the area being operated. To underscore the difference of the ground plate of a conventional electrosurgery, the ground plate used with radiowave surgery does not even need to contact the patient. It can actually be placed under the cushion of the operating room table at the patient's shoulder. This fact highlights the inherent difference between an actual ground plate and a neutral antenna.

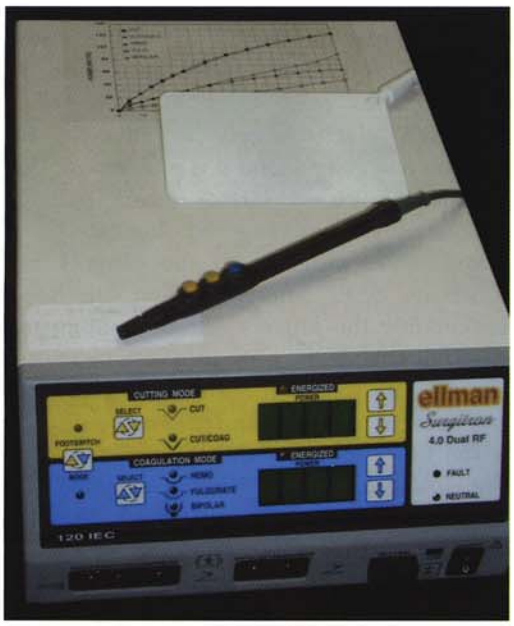

Figure 5. The Elllman Surgitron unit. The neutral antenna of the Ellman system is covered in Teflon and will not shock or burn the surgeon or the patient.

Probably the single most advantageous function of 4.0 MHz radiowave surgery is the ability to incise tissue with minimal lateral tissue damage.

Bridenstine found biopsies done with radiofrequency incision to have thermal damage zones of 75 microns.[2] Other studies have confirmed minimal tissue damage and comparable biopsy margins with scalpel excision.[17-21] Although this is a major advantage of 4.0 Mhz radiowave surgery, it is far from a singular advantage.

An additional advantage of 4.0 MHz radiowave surgery is the fact that four types of waveforms are utilized for various surgical applications. The pure cutting wave form has about 90 percent cutting with only 10% coagulation and a maximum output of 100W. This selection is ideal for skin incision. It will produce the lowest level of lateral tissue damage. Since this waveform is only 10% coagulation, more bleeding is experienced with this setting than others. This author will use the pure cutting mode for skin excision with blepharoplasty, facelift and other skin excisions then shift to the cut/coagulation mode for the deeper tissues. By using the cut/coagulation setting the surgeon is using 50% cutting current and 50% coagulation current with a maximum output of 65 watts. This mode is used by the author in blepharoplasty once the orbicularis oculi muscle is encountered or in facelift surgery once the subcutaneous tissue is exposed. By using this setting, one is still incising with less lateral tissue damage, while simultaneously coagulating the adjacent tissues. Using the pure cutting mode for the skin only incision produces a more favorable scar due to the small amount of lateral tissue damage.

Compared to other anatomical areas the high vascularity of the head and neck makes simultaneous incision and coagulation a definite advantage. This highly vascular tissue also requires the ability to use a pure coagulation modality. Although conventional electrosurgery produces excellent coagulation, we have all seen the intense heat generated in the tissues and on the electrode. It is not uncommon to have an electrosurgery tip become red hot and melt when coagulating a resistant bleeder. Coagulation is obviously paramount for any surgeon and can make the difference between a good and poor result. When coagulating tissues in the head and neck the surgeon is frequently in close approximation to significant structures such as nerves and vessels. It makes sense that the ability to coagulate in these areas with little lateral damage is a distinct advantage. This author frequently uses the pure coagulation setting (90% coagulation current, 10% cutting current with maximum output of 35 watts) even when controlling bleeding near the parotidomasseteric fascia. To show the margin of safety, the Ellman 4.0 MHz radiowave system is frequently used in neuro and spinal surgery and was used to separate Siamese twin infants in 2004 at Montefiore Hospital in New York City.

The ball electrode is also excellent for coagulating bleeding tissue. The small ball electrode can be used for specific vessels in hard to reach spaces and the large ball can be used for lager bleeding areas or to shrink tissue (figure 6). Indirect coagulation can be performed by transmitting the radiowaves through another instrument such as a tissue forceps (figure 7).

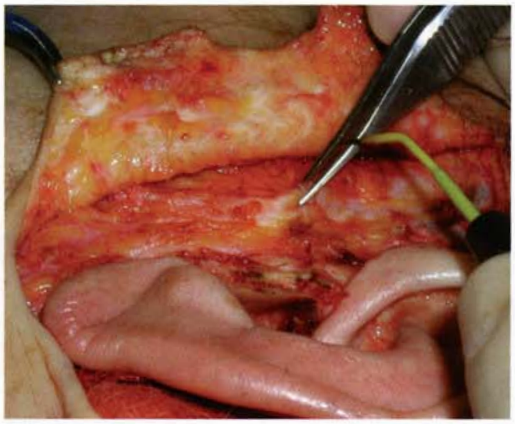

Figure 6. The 5 mm ball electrode used to coagulate and shrink protruding SMAS tissue in a facelift operation.

Figure 7. Indirect coagulation is performed by conducting the radiowave energy through metallic forceps.

By bending the malleable electrodes they can be configured to use at any angle or even around corners. Finally, coagulation can be used with bipolar mode by using the bipolar forceps.

One of the strongest points of the Ellman System is the large array of specialized electrodes. The Empire electrodes are Tungsten with a plastic insulation (figure 8).

The various configurations allow for multiple cutting angles and shaft configurations. The malleable electrodes, as stated earlier, can be shaped for required configurations. This is truly

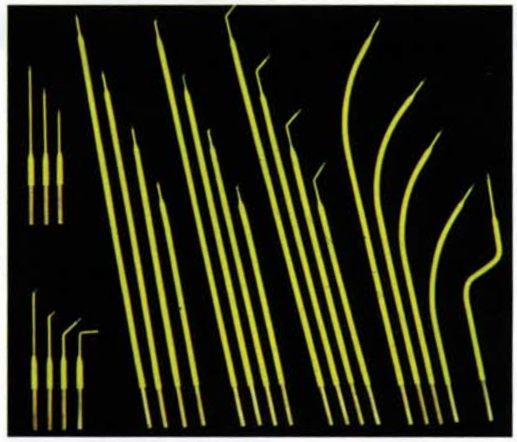

Figure 8. A vast array of Empire tungsten microneedles is available to fit numerous surgical indications and configurations.

and advantage when compared with a straight scalpel blade. This is especially useful when working in a cavity or under a flap where direct vision in difficult. The Vari-Tip electrodes consist of a very fine wire that can be extended or retracted and when used with the pure cutting mode probably produces the least amount of lateral damage. In addition, these tiny electrodes allow a pressureless incision which is especially useful when incising mobile or unsupported soft tissue. An additional benefit of radiowave surgery is that the electrodes are self cleansing. All electrosurgical instruments develop crusty debris on the tip, especially when coagulating. This is easily dealt with using radiowave surgery by placing the electrode (or bipolar forceps) in a wet gauze and firing the unit. This will cause the production of steam and automatically clean the instrument.

Procedure specific electrodes also make 4.0 MHz radiowave surgery useful. The loop electrode is useful for removing elevated lesions such as nevi. By using the loop to shave off the top of a lesion on the pure cutting mode there is no substantial artifact to negatively affect the microscopic pathology. After shaving the lesion on the pure cutting mode, the base of the lesion can be removed with the loop on the cut/coagulation setting.

The harvesting of palatal mucosa is required for multiple medical and dental procedures. This is a difficult procedure to perform manually with a scalpel. It is not only difficult to obtain a geometric graft in terms of width and depth, but this area bleeds freely. The palatal mucosal grafting electrodes provide a huge advantage for this procedure. They are constructed like a micro "cheese cutter". When pulled through the mucosa they harvest a mucosal graft of exact

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Figure 9A. The specialized palatal mucosa harvesting electrodes. The predetermined depth and width of these electrodes ensure consistent graft harvesting with excellent control.

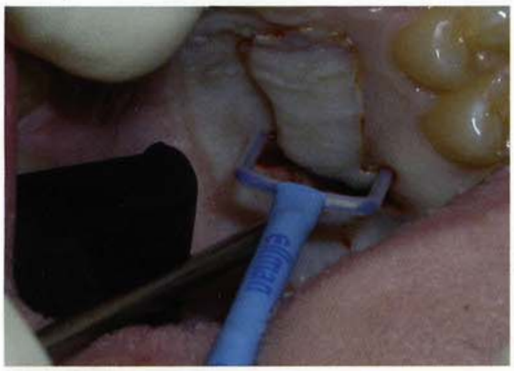

Figure 9B. An actual palatal graft being harvested.

width and depth. These electrodes come in various widths and depths (figure 9).

There is a varied assortment of electrodes for ENT and Maxillofacial procedures. A bipolar attachment for epistaxis is manufactured as well as a specialized electrode used to effectively alter the soft palatal tissues (figure 10).

This author is conducting an ongoing study comparing radiowave incision versus CO2 laser incision in blepharoplasty. Thirty consecutive patients were treated using radiowave incision in the pure cutting mode with the empire micro needle on one upper lid. The other upper eyelid was treated with the CO2 laser utilizing the 0.2 mm handpiece with a setting of 8 watts. Figure 11 shows the skin incision with the respective modalities.

Figure 11A. 4.0 MHz radiowave incision for upper blepharoplasty Figure 11B. The same incision using CO2 laser. Both modalities offer excellent hemostasis and healing.

At 3 months there was no significant difference between either modality. Considering this, the radiowave system offers numerous advantages. The radiowave is about 1/6 the cost of the laser and requires less safety precautions compared to the laser. It is also portable and easier to set up and operate. Figure 12 shows a typical example of the post operative scars. This image was taken 6 months after surgery using radiowave incision on the left eyelid and CO2 laser incision on the right eyelid.

When using the pure cutting mode the Ellman

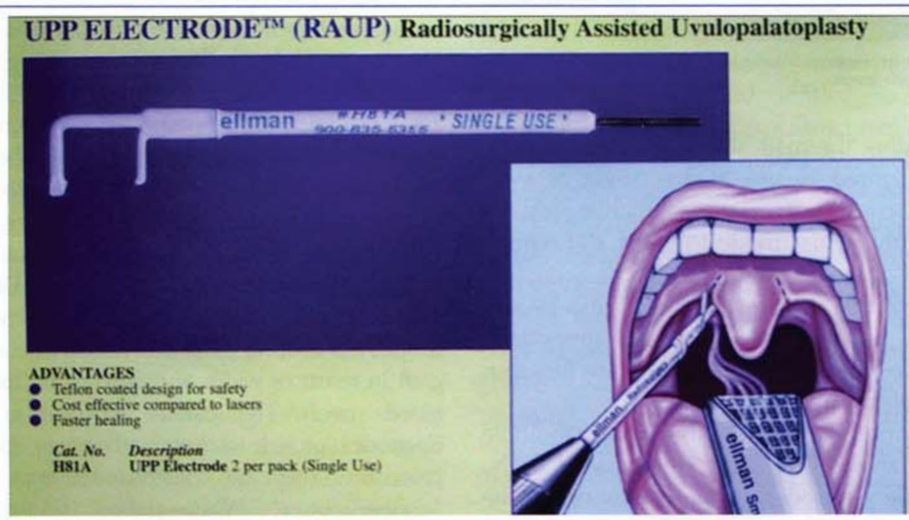

Figure 10. The dedicated electrode designed for uvulopalatopharyngoplasty.

Figure 12. RF/CO2 study patient at 6 months post blepharoplasty. The left upper eyelid was incised with the 4.0 MHz radiowave microneedle and the right upper eyelid was incised with the CO2 laser with a 0.2 mm handpiece.

Radiowave System also has advantages in other cosmetic procedures. This author frequently uses the Empire micro needle for rhytidectomy surgery.

Figure 13. The Ellman 4.0 MHz radiowave surgery Empire microneedle on a pure cutting mode provides excellent healing of cosmetic incisions consistent with scalpel healing.

This author uses the small ball or the #133 electrode to remove facial lesions. If they are suspicious, they are first shave biopsied with a loop electrode set on pure cutting or a scalpel blade. The unit is then set on pure cutting and the nevus is gently reduced by light sweeping motions with the tip. The assistant debrides the char between passes and the surgeon continues to ablate the lesion down to a flat base or with a very slight concavity. (Figures 13 & 14)

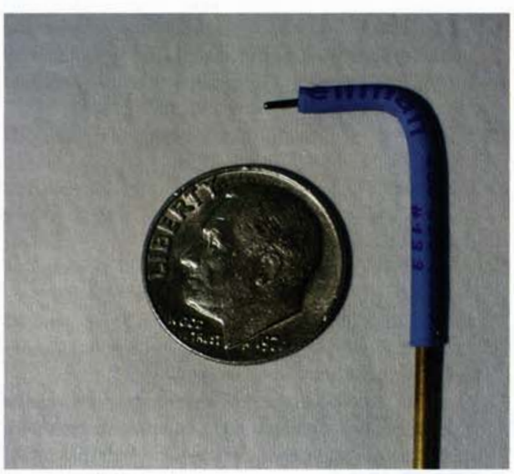

Figure 14. The Ellman #133 electrode is frequently used by the author to ablate nevi and other cervicofacial lesions.

Figure 13.

HAZARDS, COMPLICATIONS AND CAVEATS

As with any modality radiowave surgery presents potential hazards and complications. Excess lateral tissue damage is probably the most common complication and usually results from operator error (especially novice clinicians) by failing to observe simple rules. Choosing optimal power settings, the correct electrode and ensuring continuous movement with care not to pass too slowly through the tissue will prevent increased tissue damage.

Radiowave surgery should not be used in the presence of flammable anesthetics, liquids or skin preparations.

Just as the laser plume can be detrimental, radiowave surgery causes tissue vaporization and potential smoke hazard from particulate inhalation. Precautions include careful and controlled smoke plume evacuation and wearing surgical masks rated for micro-particle filtration. Although not a complication, inadequate removal of smoke will cause an unpleasant smell throughout the office. If central suction is used, it must be vented to the outside environment otherwise you are merely redistributing the smoke and smell from one area of the office to another. Special portable evacuation systems are available with viral and activated charcoal filters for both operator and patient safety and comfort.

Radiowave surgery machines may also interfere with other electromedical equipment such as monitors. In the author's office interference with the EKG monitor was corrected by plugging the radiowave machine into a separate circuit from the EKG.

Pacemaker interference has been a major concern in the past but is only a problem with older non-shielded pacemakers. Most modern pacemakers are shielded from external radiation and therefore are not a problem. There exist several surgeons that themselves have implanted pacemakers and routinely operate with radiowave surgical units without problem.[23]

The potential exists for interference with

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implantable cardioverter-defibrillators (ICDs). LeVasseur et al, have reviewed this topic and make recommendations including possible deactivation of the ICD prior to surgery.[24] The electromagnetic interference of radiowave surgery may cause the pacemaker to reprogram or otherwise malfunction. In the case of ICDs the interference may cause the device to fire a cardioversion sequence or reprogram the device. In the case of an ICD discharge the surgeon is in no danger of electrical shock because the discharge is not transmitted but it may induce dysrrhythmias in the patient.

When radiowave equipment is used in the presence of cardiac pacemakers or defibrillators a cardiology consult should be obtained. It is possible that the cardiologist may elect to temporarily inactivate the device during the surgical procedure. Intraoperative cardiac monitoring as well as availability of emergency cardiac medications should be on hand in the rare case of a cardiac emergency. Bipolar usage of radiowave surgery is safer when operating on pacemakers and ICDs as the current is concentrated across the tips rather than through the patient. Short bursts of radiowave surgical energy (less than 5 seconds) are preferable to long electrode activation periods. Pauses between the bursts allow resumption of cardiac rhythm.[25]

CONCLUSION

4.0 Mhz Radiowave surgery is a new technology that offers many advantages for the cosmetic surgeon. The greatest single advantage is the ability to incise tissue with minimal tissue damage. The ability to cut with simultaneous coagulation is also a significant benefit. A vast array of specialized electrodes, affordability, portability, and minimal safety issues makes this technology a useful addition to most practitioners.

Advantages of Radiowave Surgery

- Incision without applying pressure (pressureless incision)
- Simultaneous hemostasis
- Bacterial free incision
- Artifact reduction in biopsy compared to electrocautery
- The ability to bend or shape the cutting electrode for anatomical variation or working in cavities
- Produces a scar equal to or better than scalpel or laser incisions
- Pays for itself over time in not having to purchase scalpel blades
- No accidental scalpel injuries
- No dealing with dull scalpel blades
- Minimal safety precautions when compared to lasers
- No danger of ground plate burn to patient
- Self cleansing

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*** No competing interests have been disclosed by the author.**