Radiowave Surgery versus CO_2 Laser for Upper Blepharoplasty Incision: Which Modality Produces the Most Aesthetic Incision?

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INTRODUCTION For years, traditional upper blepharoplasty incisions have been made with scalpel and or scissors. Although effective, increased intraoperative bleeding can be problematic. Bleeding slows the surgery; obscures the surgical field; and can lead to increased swelling, bruising, and pain. Bloodless modalities for upper blepharoplasty include radiowave surgery, electrocautery, and CO_2 laser technology. These modalities provide a virtually dry and bloodless surgical field, which translates into faster surgery as well as decreased postoperative bleeding, bruising, and pain.

PURPOSE The purpose of this study was to determine which modality (CO_2 laser vs. 4.0-MHz radiowave surgery) produced the most aesthetic postoperative upper blepharoplasty scar at 1 year in a consecutive cohort of patients operated by the same surgeon. A search of the literature does not show a similar study in Caucasian patients. The mechanics and physics of CO_2 laser and 4.0-MHz radiowave surgery are also discussed.

MATERIALS AND METHODS Thirty consecutive patients underwent upper eyelid blepharoplasty for cosmetic purposes performed by the author. In all patients one upper eyelid was treated (skin, muscle, and fat) with a 4.0-MHz radiowave surgery unit (Surgitron, Ellman International) set at 12 W on the cut/coag mode, and the contralateral side was treated with an ultrapulse CO_2 laser (Encore, Lumenis Inc.) using a 0.8-mm handpiece on the continuous wave setting at 8 W. Six blepharoplasty-experienced, blinded observers consisting of doctors from five different cosmetic specialties evaluated standardized digital images of each patient taken 1 year after surgery. The photographs were randomized, and the blinded examiners were asked to choose the side that had the most esthetic postoperative incision.

RESULTS Of the 30 consecutive patients, 23 completed the required 1-year follow-up. Surgeons evaluating these patients scored the radiowave surgery side to look best in 37% of the cases (43/115), the CO_2 laser side was scored to look better in 37% (42/115), and both sides to be to be equally aesthetic in 26% of the cases.

CONCLUSION Both 4.0-MHz radiowave surgery and CO_2 laser incision produce simultaneous incision and coagulation. Both modalities restrict blood loss in the average four lid blepharoplasty surgery to less than 1 cm^3 of blood and decrease operative time. In this study, qualified blinded surgeons judging 12-month postblepharoplasty photos of incisional scars were unable to differentiate a statistically significant difference between the two modalities and the aesthetic quality of the scars. This represents the first study of its type in the literature utilizing Caucasian patients.

The authors have indicated no significant interest with commercial supporters.

Cosmetic blepharoplasty remains one of the most common and popular procedures for aesthetic and functional reasons. Multiple incisional modalities have been used over the years including scalpel, scissors, cautery, electrosurgery, radiowave surgery, and lasers and have been discussed and compared in the scientific literature.[1–9] Using cold steel or scissors produces aesthetic results but does not provide simultaneous hemostasis with incision. The profound vascularity of the periorbital region causes significant bleeding when incised with modalities that do not provide simultaneous hemostasis. This bleeding can obscure the surgical site and therefore extend the procedure time and result in less accurate visualiza-

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tion. In addition, increased bleeding is associated with increased postoperative edema, ecchymosis, and discomfort.[4,6] In some cases postoperative bleeding can lead to minor complications such as hematoma or major complications such as retrobulbar bleeding. It is to the advantage of both the surgeon and the patient to utilize operative modalities that will minimize hemorrhage and cause minimal lateral tissue damage. The latter can be associated with the final quality of the surgical scar. This study was designed as a qualitative observation of mature blepharoplasty scars as judged by a diverse group of trained surgeons as to which modality (if either) produced a more superior postoperative scar.

Both CO_2 laser and 4.0-MHz radiowave surgery (also called radiofrequency surgery or radiosurgery) have been successfully utilized for simultaneous incision and coagulation in upper blepharoplasty surgery. The purpose of this study was to evaluate which of the above modalities proved the most aesthetic postoperative surgical scar. The same upper blepharoplasty procedure was performed on 30 consecutive patients using 4.0-MHz radiowave surgery with a tungsten needle tip microelectrode on one eyelid and CO_2 laser incision with a 0.2-mm handpiece on the contralateral eyelid. A Medline search did not yield any split lid studies examining postblepharoplasty scars using CO_2 laser and 4.0-MHz radiowave surgery on Caucasians although a similar study on Asian eyelids has been reported.[1]

Materials and Methods

All of the patients in this study consented to cosmetic upper blepharoplasty with either modality and were in good general health with normal coagulation studies (prothrombin time, partial thromboplastin time, and international normalized ratio). The study protocol conformed to the guidelines of the 1975 Declaration of Helsinki and was approved by our institutional review board. No patient reported any significant ophthalmologic pathology or conditions that would preclude blepharoplasty, and the ophthalmologic exam of all patients was within normal limits for the procedure. The patients were instructed to refrain from any medication, herb, or homeopathic product that is known to affect clotting for at least 2 weeks preoperatively. Standardized digital photography was performed with a digital camera (Olympus, Center Valley, PA) specially designed for clinical macro photography (Lester Dine Inc., Palm Beach Gardens, FL) utilizing seven-megapixel resolution. All pre- and postoperative digital images were taken by the author using the same camera, camera settings and focal distance, background, and ambient lighting.

Surgical Procedure

On the day of surgery, the patients were photographed in the standing position with the brows relaxed with the eyes in the neutral position. The eyelids were marked with a surgical marker to leave at least 20 mm of residual eyelid skin after excess skin resection. All patients were treated with intravenous sedation using propofol, ketamine, meperidine, and midazolam, titrated to a level consistent with conscious sedation with the spontaneous maintenance of their airway.

After sedation, the patients were properly prepped and draped and 2 mL of 2% lidocaine with 1:100,000 epinephrine was injected subcutaneously on each upper eyelid. After two drops of proparacaine, appropriate corneal protection (plastic shields for the radiofrequency lid and metal shields for the CO_2 lid) were placed.

Radiowave-Treated Eyelid

In all cases, the left eyelid was incised with a 4.0-MHz radiowave system (Surgitron, Ellman International, Oceanside, NY) with a tungsten tapered microneedle tip electrode. The setting was 11 W on the cut/coagulation setting (50% cutting and 50% coagulation). The same machine and electrode type was used on all patients and the author operated on all eyelids on all patients. Using the cut/coagulation setting, the required, premarked skin was incised to the level of the orbicularis oculi

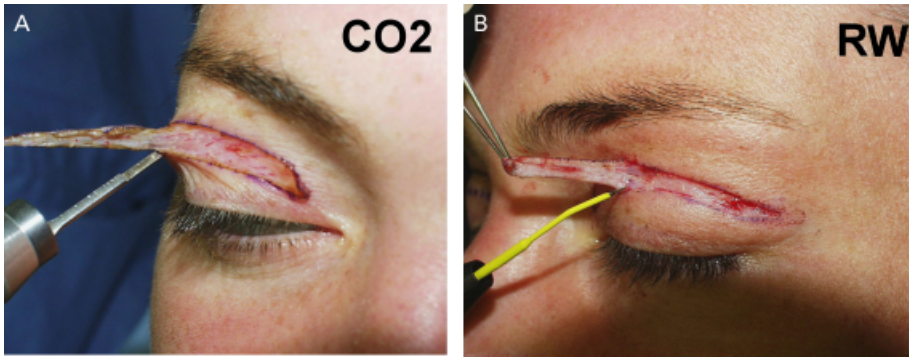

Figure 1. (A) Skin excision with CO_2 laser and (B) skin excision with the radiowave (RW) microneedle.

muscle. The edge of the skin ellipse was secured with a tissue pick up, and the skin was dissected from the underlying muscle with the radiowave setting now on pure coagulation. A 4- to 5-mm strip of orbicularis oculi muscle was then excised with the radiowave unit again on pure coagulation. The orbital septum was identified and incised on the same setting, and the medial and central fat pads were conservatively excised, reduced, and recontoured with the same electrode tip on the pure coagulation setting. The surgical site was checked for hemostasis and the incisions were closed with a running 6-0 nylon suture on all patients.

CO_2 Laser–Treated Eyelid

The right eyelid in all cases was incised in the same manner using a CO_2 laser (Encore Ultrapulse, Lumenis Inc., Santa Clara, CA) with a 0.2-mm handpiece on a continuous wave setting of 8 W. The skin, muscle, and fat were similarly incised as described with the radiowave treatment. When incising muscle or excising fat, the laser beam was defocused to assist hemostasis. This effectively changes the spot size and delivered energy to the target tissue.

Figures 1 to 3 show the comparative modalities utilized in the study, not the blood-free surgical fields with both modalities. The exact same postoperative instructions and wound care were utilized for both eyelids on all patients. Postoperative care included limited activity and ice packs for the first 48 hours. Instructions for routine wound care, consisting of wiping suture lines twice a day with hydrogen peroxide and coating incisions with triple antibiotic ointment, were given to all patients. Patients were scheduled for suture removal 5 days after surgery. No patients with either modality experienced any significant postoperative complications or wound dehiscence.

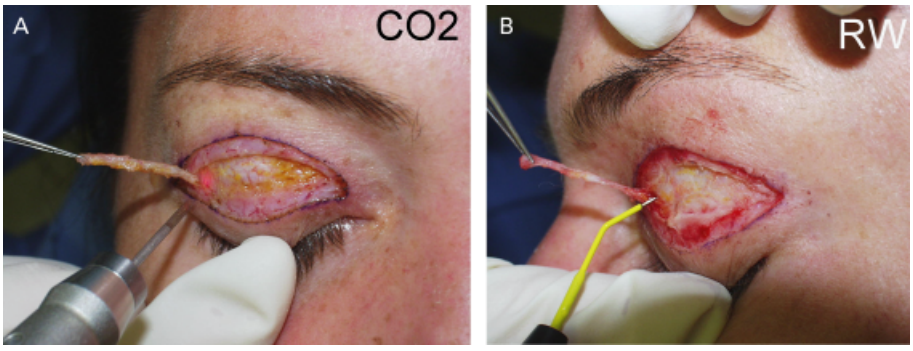

Figure 2. (A) Orbicularis oculi muscle excision with CO_2 laser and (B) muscle excision with the radiowave (RW) microneedle.

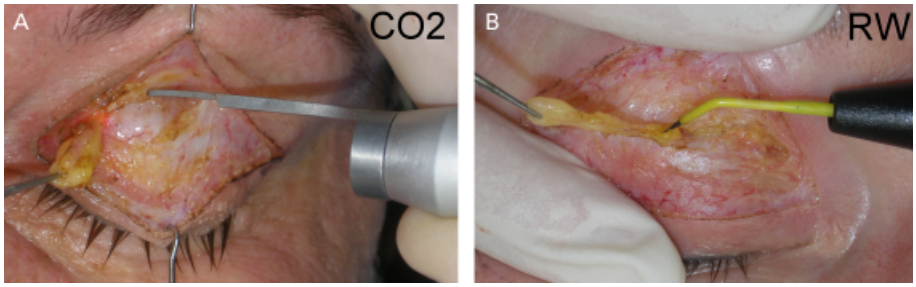

Figure 3. (A) Fat pad excision with CO_2 laser and (B) fat excision with the radiowave (RW) microneedle.

The author saw all patients on Day 5 (suture removal), 1 month, 3 months, 6 months, and 12 months postoperatively. Standardized digital photographs were taken by the author with the previously described controls at all postoperative visits. The postoperative photos were taken with the patients with their brows maximally elevated to visualize the blepharoplasty scars.

Analysis

Of the 30 consecutive patients, 23 completed the required 1-year follow up. (Of the 7 patients disqualified, 1 moved out of state and reported excellent results on both lids. The other patients have been seen since the surgery but since they could not reliably make the exact required postoperative photographic appointments, they were not used in the study. None of these patients reported problems or complications with either incision side.) During the first 30-day period, the author observed one side or the other occasionally had a more aesthetic scar with no significant repeating correlation. At 90 days, both scars on all patients seemed to mature to the final result, and no significant difference in healing or scar aesthetics was observed at subsequent follow-up (Figure 4).

The 12-month postoperative images were printed on premium plus photo paper at the highest quality setting using a color inkjet printer (HP 5500, Hewlett-Packard Inc., Palo Alto, CA). The digital images were then presented to five board-certified surgeons with at least a decade of blepharoplasty experience. The reviewers represented plastic surgery, facial plastic surgery, oculoplastic surgery,

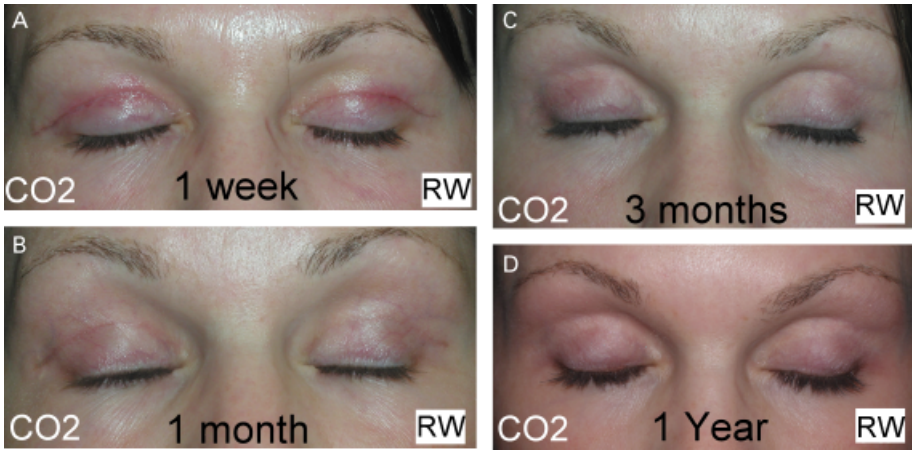

Figure 4. (A) The same patient (CO_2 patient's right lid, radiowave [RW] patient's left lid) at 1 week (A), 1 month (B), 3 months (C), and 12 months (D).

dermatology, and oral and maxillofacial surgery (the author did not participate in the study). The reviewers were blinded as to what technique or modality was employed as well as any parameters of the study. The reviewers were simply asked to "evaluate each patient as to which eyelid had the most aesthetic postblepharoplasty scar." A preprinted form allowed the choice of:

- Right side eyelid scar looks better
- Left side eyelid scar looks better
- Both eyelid scars look the same

Results

Five blinded experienced surgeons from multiple specialties evaluating the 12-month postoperative images rated the radiowave surgery side (left eyelid) to look more aesthetic in 37% of the cases (43/115), and the CO_2 laser side (right eyelid) was scored more aesthetic in 37% of the cases (42/115). Observers found both sides to be equally aesthetic in 26% of the cases (Table 1). The computed chi-square analysis of the reported frequencies accepted the null hypothesis ($p = 1.00$) indicating that there was no difference between the interventions noted by the outcome judged by observers. This means that in this study neither CO_2 laser or 4.0-MHz radiowave surgery demonstrated statistical significance in superiority of postblepharoplasty incision aesthetics.

TABLE 1. Tabulated Results with Chi-Square Analysis

Chi-Square Results

	Better Result	*Lesser Result*	*Same Result*	*Total*
Right eye	43	42	30	115
Left eye	42	43	30	115
Total	85	85	60	230

Degrees of freedom: 2.
Chi-square = 0.0235294117647059.
For significance at the .05 level, chi-square should be greater than or equal to 5.99.
The distribution is not significant.
p is less than or equal to 1.

Figure 5. Observers typically scored this image as the radiowave side (patient's left lid) as being superior.

Typical images that the reviewers selected as CO_2 superior, radiofrequency superior, or equally aesthetic scars are shown in Figures 5 to 7.

Discussion

Cosmetic blepharoplasty of the upper eyelids has long been a mainstay of aesthetic surgery practitioners and remains one of the most requested functional and aesthetic procedures. Contemporary incisional techniques include scalpel, scissors, electrosurgery, battery-powered diathermy, CO_2 laser, and radiowave surgery.[10,11] Given the intense vascularity of the face and periorbital regions, intraoperative bleeding can complicate this procedure. Increased intraoperative bleeding is

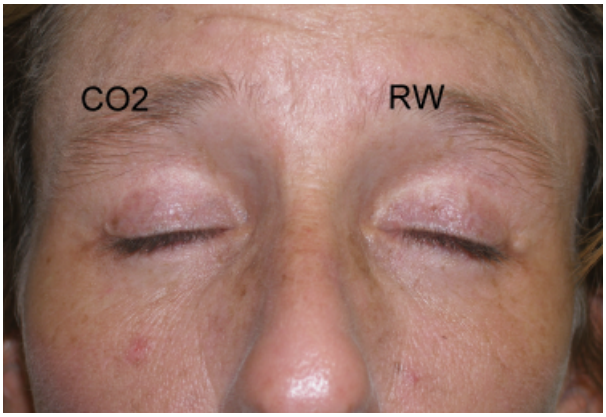

Figure 6. Observers typically scored this image as the CO_2 laser side (patient's right lid) as being superior.

Figure 7. Observers typically scored this image as both scars being equally aesthetic.

problematic in many ways including obscured surgical field, increased chance of postoperative bleeding with possible retrobulbar hematoma,[12–14] and increased postoperative bruising. Most surgeons associate increased intraoperative and postoperative hemorrhage with increased postsurgical complications including protracted swelling and pain.[4,6] In addition it seems logical that a surgeon can perform more accurate and less stressful surgery in a bloodless surgical field. Although many surgical procedures can be performed without fear from minor postoperative bleeding, retrobulbar hematoma is a serious complication that can lead to blindness and is always a consideration with postoperative bleeding in blepharoplasty patients. "The eye must be dry" is a mantra of absolute importance in periorbital surgery.

Upper eyelid skin incisions and resultant muscle and fat excision are frequently performed with scalpel and or scissors. Although sharp cold steel incisions do not require expensive or complex armamentarium, they no doubt bleed more than light-based or electrical incisional modalities. CO_2 laser incision with a microspot handpiece and "electrosurgery" incisions are common in contemporary blepharoplasty surgery. They both provide the advantage of simultaneous incision and coagulation for skin and muscle and are invaluable for cauterization and recontouring and removal of periorbital fat. Yu and colleagues[1] performed a similar study on 20 Asian eyelids and found similar results. Their study showed decreased operative time and increased hemostasis with the CO_2 laser, but both eyelid scars healed equally at 3 months. Their excellent study included only Asian patients and results were only evaluated by a single assessor, whereas the current study involved only Caucasian patients and results were judged by five assessors from five different specialties whose purview includes cosmetic blepharoplasty.

Mechanics of Incision with Simultaneous Hemostasis

Radiowave Surgery The optimum radiosurgery wavelength is a frequency of 4.0 MHz, which is similar to the frequency of marine band radios.[15,16] Radiofrequency surgery at 4.0 MHz should not be confused with conventional electrosurgery, electrocautery, or diathermy surgery. With radiofrequency surgery, no electrical contact needs to be made between the patient and the Teflon-coated neutral antenna, and the patient cannot be burned or shocked. The antenna does not even need to touch the patient. Unlike the electrocautery, the radiofrequency cutting electrode does not provide resistance and remains cold. It is the tissue that provides the resistance. Impedance to the passage of the radiowaves through the tissue generates heat within the cells, which boils intracellular tissue water, creating steam, and the resulting vaporization results in either cutting or coagulation of tissue.[15] The steam generated from the energy transfer causes the cell inner pressure to increase from the inside out (explosion). This phenomenon is referred to as intracellular volatilization.[16] The radiowave frequency does not cause the actual electrode to heat, but precisely delivers the energy. The high-frequency radiowaves are modified by filtering and rectification to produce four distinct wave forms. The author utilizes the blend setting (cut/coag) for skin incision and the pure coagulation for muscle and fat excision and recontouring when performing blepharoplasty. Using the pure cutting setting for skin incision would theoretically produce less tissue damage, but is not a bloodless incisional modality.

When compared to radiowave surgery, an electrosurgical cautery machine uses lower frequencies. The electrode filament provides the resistance and is heated as the current is passed through. Experienced surgeons have seen hospital electrosurgical machines heat the electrode tip red hot or sometimes melt due to the extreme heat. This arrangement provides significant lateral tissue damage. Since radiofrequency generates less heat than conventional cautery, less collateral damage is seen and therefore faster healing. Multiple studies have compared electrosurgery against laser and scalpel modalities. Radiowave surgery has been shown to be an improved modality in soft tissue surgery.[17–24] Bridenstine[17] found biopsies done with radiofrequency incision to have thermal damage zones of 75 m, which is comparable to CO_2 laser. Another study has confirmed minimal tissue damage and comparable biopsy margins with scalpel excision.[24]

CO_2 Laser The CO_2 laser emits a wavelength of 10,600 nm, which is transmitted through a series of mirrors and lenses to achieve a small concentrated spot size that can ablate or vaporize tissue. The target of this CO_2 wavelength is water. Photothermal ablation (vaporization) occurs when the water in tissue reaches a temperature at or above 100°C.[26] Photovaporization is used for incision and removal of tissue with superpulsed and ultrapulsed CO_2 lasers.

Photocoagulation is light-based hemostasis and is used in blepharoplasty surgery to control tissue oozing or frank venous or arterial bleeders of small to moderate size. The coagulation is controlled by modifying the geometry of the laser beam by focusing or defocusing the collimated laser beam. If the irradiance within the focused spot is high enough, photothermal ablation (incision) occurs. By moving the focal point a small distance above the tissue surface (defocusing), the reduction of irradiance caused by the increase of the spot size of the beam on the tissue surface prevents the temperature of the tissue rising above the threshold for ablation. This is a simple and effective method for cauterization of small bleeders, but is less effective with pooling of blood.

The use of the CO_2 laser has expanded in cosmetic facial surgery, and carbon dioxide lasers have gained a prominent position in their use in cosmetic blepharoplasty. The use of the CO_2 laser for blepharoplasty was first described by Baker and colleagues in 1984.[27] Advantages are a reduction in bruising, swelling, shorter recovery, and increased visualization of tissues intraoperatively. In 1987, David and Sanders,[6] in split lid studies, reported improved results on the CO_2 laser lid than on the other side which was treated with a scalpel/cautery technique. In 1992, Morrow and Morrow[5] compared laser blepharoplasty with conventional techniques in a contralateral study and stated the laser was superior. In 1994, Beeson and coworkers[28] showed CO_2 laser to be advantageous in terms of decreased bruising, swelling, and decreased operating time when compared to contralateral electrocautery. Glassberg and colleagues[4] published similar findings in 1995.

Which Device Is Better?

Both of the described incisional modalities serve as useful tools for skin and soft tissue incision with simultaneous hemostasis. Reducing intraoperative bleeding during incision has multiple and notable advantages including better surgical field visualization; decreased intra- and postoperative hemorrhage; and decreased ecchymosis, edema, and pain.

According to the results of this study, either modality will produce an aesthetic surgical postblepharoplasty scar that is indistinguishable from the other. As to which modality is truly the best to use is more subjective on the specific surgeons' situations and preferences.

In terms of economics and portability, the 4.0-MHz radiowave machine is more advantageous. At about the size of a VCR and the approximate cost of $11,000, it is more affordable and portable when

compared to CO_2 lasers, which can cost upwards of $100,000 and can weigh hundreds of pounds. Although both modalities produce a smoke plume that must be evacuated, the laser requires more safety precautions including wavelength-specific eye wear and the hazard of beam scatter and or reflection. An additional advantage of the radiowave surgery system is increased hemostatic ability. Although the CO_2 laser can provide excellent control of bleeding, it can be problematic when significant arterial bleeding is encountered. Since the laser chromophore is water, a pumping arterial bleeder with a resultant pool of blood can absorb the laser energy mitigating the hemostatic effects. The author has, numerous times, encountered arterial pumping bleeders in blepharoplasty surgery (especially in the lower lid with a transconjunctival approach) that could not be stopped with the defocused laser beam and required the radiowave electrode or radiowave bipolar forceps to control.

The laser beam also has the problem of "overshoot," where the beam can pass by the intended tissue and burn nontarget tissue. Burning the lateral nose while lasering in the medial canthal area is an example. Although both modalities could ignite flammable gases, the laser is more problematic in terms of ignition of hair, linen, drapes, etc.

The radiowave system has advantages in point of contact in that the radiowave electrodes can be bent to negotiate curves and cavities and there is a wide array of tips available. The laser has one tip and size and must be used relatively perpendicular to the tissue surface. The radiowave handpiece is lightweight and provides a pressureless incision. The CO_2 laser handpiece also produces a pressureless incision but is tethered to a sometimes cumbersome articulated arm, which can be awkward at certain angles. The CO_2 laser can be loud and produces operational heat that can raise the room temperature. It also has sensitive components that require regular maintenance and are expensive to service and repair. The radiowave unit is solid state and has no movable parts or mirrors to move from alignment. It is quiet and does not produce significant heat. Considering these comparisons, one could construe that the 4.0-MHz radiowave system is more versatile.

For a surgeon who performs simultaneous CO_2 laser skin resurfacing of the periorbita or full face in conjunction with blepharoplasty, the laser may be preferable modality because only one machine needs to be utilized, set up, plugged in, etc. In addition, radiowave surgical machines can conflict with other electronic devices such as EKG (electrocardiogram) monitors where the normal wave form is altered when the radiowave machine is activated. This can sometimes be lessened by plugging the radiowave machine into a separate circuit. The anesthesia personnel must be aware of these possible changes. Radiowave generation can also be problematic with cardiac pacemakers and internal cardiac defibrillators (ICD).[29–33] Older, not-shielded pacemakers could be interrupted by radiowaves but contemporary pacemakers are shielded and are not generally problematic. In fact, there are surgeons who have internal pacemakers and are frequent users of radiowave machines without problems (personal communication, Jon Garito, Ellman International, January 2000). ICDs can be a bigger problem with radiowave interference and should not be used with any electrical surgical device without preoperative consultation.

Summary

According to the results of this observational study, CO_2 laser and 4.0-MHz radiowave surgery produce postoperative blepharoplasty scars that are equally esthetic. When examining 46 eyelid scars on 23 patients, experienced observers could not identify a more aesthetic scar in 26% of the patients. The laser scars were judged superior in 37% of the patients, and the 4.0-MHz radiowave surgical scars were judged as more aesthetic in 37% of the patients. This did not pose a statistically significant difference.

Because this study was purely qualitative and the reviewers examined images as opposed to actual

patients, various design flaws must be taken into account. The loss (albeit it minor) of reproducibility of digital equipment such as cameras and printers could affect the reviewers' judgment of aesthetic superiority of the various incisions images. This study was also subjective in that the reviewers' opinions were more of a "gestalt" as to gross visual incision aesthetics as opposed to highly quantitative methods that could include histology, surface analysis, elastomeric or colorimetric studies, etc.

A blended cut/coagulation current setting was used in this study. Using a pure cutting setting would likely provide less lateral tissue damage, but does not produce the simultaneous hemostatic effect desired by the author. Although not published in a Medline journal, Welch and Bryar[34] compared CO_2 laser blepharoplasty incision and 4.0-MHz radiowave surgery with histologic study using the pure cutting mode. Their histologic specimens showed the thermal necrosis zone of 202 μm for the ultrapulsed laser and 135 μm for the 4.0-MHz radiowave incision.[34]

Iatrogenic tissue damage from either modality could be caused by operator error. Using excessive power settings with either laser or radiowave surgery could cause increased lateral tissue damage, thus affecting the final healing and scar. In addition, moving the radiowave electrode or the CO_2 laser handpiece at too slow of a rate across the incision could also cause increased lateral tissue damage, affecting healing and scarring. In this case, all of the incisions were made by the same surgeon, experienced in both modalities, but in clinical practice an inexperienced surgeon may obtain skewed results. Individual patient healing variations, although immeasurable, could also affect the final scar and therefore the validity of this study.

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