Comparative Healing of Surgical Incisions Created by the PEAK PlasmaBlade, Conventional Electrosurgery, and a Scalpel

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Background: The PEAK PlasmaBlade is a new electrosurgical device that uses pulsed radiofrequency to generate a plasma-mediated discharge along the exposed rim of an insulated blade, creating an effective cutting edge while the blade stays near body temperature.

Methods: Full-thickness incisions were made on the dorsums of pigs with the PlasmaBlade, a conventional electrosurgical device, and a scalpel, and blood loss was quantified. Wounds were harvested at designated time points, tested for wound tensile strength, and examined histologically for scar formation and tissue damage.

Results: Bleeding was reduced significantly (59 percent) in PlasmaBlade incisions compared with scalpel incisions, and acute thermal damage from the PlasmaBlade (66 ± 5 μm) was significantly less than both cut and coagulation mode electrosurgical incisions (456 ± 35 μm and 615 ± 22 μm, respectively). Histologic scoring for injury and wound strength was equivalent between the PlasmaBlade and scalpel incisions. By 6 weeks, the healed PlasmaBlade and scalpel incisions were approximately three times stronger, and scar cosmetic appearance was significantly better compared with electrosurgical incisions.

Conclusions: The PlasmaBlade is a promising new surgical instrument that provides atraumatic, scalpel-like cutting precision and electrosurgical-like hemostasis, resulting in minimal bleeding, tissue injury, and scar formation. (*Plast. Reconstr. Surg.* 124: 1849, 2009.)

The most widely used cutting instrument in surgery is the scalpel; however, scalpel incisions are prone to bleeding that obscures the operative field. Electrosurgical cutting tools date to the 1920s and are now used in more than 17.5 million procedures per year in the United States alone.[1] Conventional electrosurgery uses continuous-waveform radiofrequency energy delivered by means of an electrode to "incise" tissue by thermal ablation, which also produces simultaneous hemostasis.[2,3] Although this hemostatic capability represents a major advance, there are a number of disadvantages associated with electrosurgery, including lack of surgical precision, thermal injury to adjacent tissues such as nerves and blood vessels, and delayed wound healing.[4–12]

Consequently, a number of new electrosurgical technologies have been introduced, such as insulated cutting electrodes, ultrasonic blades, and feedback-controlled radiofrequency generators.[5–9,12] Some of these developments have demonstrated incremental improvements in reducing the thermal damage while preserving hemostatic ability. However, substantial room for improvement remains in electrosurgical technology that can approach the surgical precision and favorable wound-healing

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characteristics of the scalpel while also providing hemostasis.

Whereas conventional electrosurgical devices cut with continuous waveforms, the pulsed electron avalanche knife[13] operates with cyclic bursts lasting from 10 to 100 msec. To allow for efficient cooling, the burst repetition rate does not exceed 1 kHz and thus a typical duty cycle (fraction of time the energy is delivered) does not exceed 5 percent. The radiofrequency pulses induce a plasma-mediated discharge along the exposed edge of a thin (10 to 50 μm), flat, 99.5 percent insulated electrode.[14,15] This plasma rim provides a cutting edge for precise tissue dissection with simultaneous hemostasis. Because of the reduced duty cycle and the small exposed area of the electrode, pulsed electron avalanche knife technology yields a much lower average power output and uses less total energy than conventional electrosurgery to achieve an equivalent rate of tissue cutting, thus reducing collateral thermal damage.[14,15] Although pulsed electron avalanche knife technology has been evaluated previously on ophthalmic tissues,[13,16–21] its effects on cutaneous wound healing remain unknown.

In the present study, we hypothesized that the unique features of the PlasmaBlade (PEAK Surgical, Inc., Palo Alto, Calif.) would have a superior wound-healing profile compared with standard electrosurgery. Thus, we investigated the healing profile of incisions created by a traditional scalpel, conventional electrosurgery, and the PlasmaBlade using an established porcine skin model.[12] We examined objective parameters including blood loss, wound tensile strength, histologic coagulation necrosis, and inflammation. In addition, we evaluated instrument operating temperature, wound cosmesis, and scarring.

MATERIALS AND METHODS

Infrared Analysis of the Instrument Operating Temperatures

Infrared temperature analysis was performed by Elastic Design, LLC (Redwood City, Calif.). Images were captured using a Thermavision SC600 camera (FLIR, Wilsonville, Ore.) in the mid-infrared (3 to 5 μm) spectral range. The rate of motion during imaging was approximately 0.5 to 1 cm/second, similar to the cutting speed during skin surgery. Images were processed using MATLAB R2008 software (The MathWorks, Natick, Mass.).

Surgical Procedure

The study was conducted on six healthy Yucatan swine weighing 30 to 40 kg at study onset. The study protocol was approved by an institutional animal care and use committee and conducted in accordance with the Animal Welfare Act and the National Institutes of Health *Guide for the Care and Use of Laboratory Animals*. The animals were acclimated for 72 hours and fed a standard diet once daily. Anesthesia was induced using ketamine (15 mg/kg) (MWI Veterinary Supply, Meridian, Idaho) and atropine (0.04 mg/kg) (MWI Veterinary Supply), and Telazol (6 mg/kg) (MWI Veterinary Supply) for the final wounding before the animals were killed. After endotracheal intubation, anesthesia was maintained with inhaled isoflurane, and animals were prepared and draped in standard sterile fashion for each of the five surgical procedures on days 0, 21, 28, 35, and 42. The surgical procedure at each time point consisted of one incision made with a scalpel, the PlasmaBlade, and electrosurgical cut and coagulation modes. Each set of incisions was considered to be an independent study point. The timing of the surgical procedures allowed for wound-healing data points at 1, 2, 3, and 6 weeks as the animals were killed immediately after the surgical procedure on day 42 (i.e., incisions made on day 0 harvested at day 42 represent the 6-week time point).

Incisional Wound Model

Full-thickness skin incisions 3 cm in length were made on the dorsum of each animal. The medialmost incision was placed 3 cm from the dorsal spinal processes, with each subsequent incision placed 2 cm lateral to the prior incision, all in a parallel orientation. Differences in skin thickness were controlled for by rotating the instrument cutting order. Incisions were made with the PlasmaBlade using the PULSAR Generator (PEAK Surgical) on cut setting 3 (6 W), a no. 10 scalpel blade (Bard-Parker, Franklin Lakes, N.J.), and the Valleylab Electrosurgical Pencil using a Force 2 Generator (Valleylab, Boulder, Col.) on cut (40 W, Blend 2) and coagulation (40 W, Spray) modes. Extensive pilot studies were performed to determine the optimal power setting for the electrosurgery unit. Multiple power settings were used, including 20, 50, and 75 W. Interestingly, all three power settings had similar widths of thermal damage (data not shown). On the coagulation setting, the lower power setting led to increased thermal injury because of prolonged contact of the hot tip with the tissue (data not shown). The preliminary studies indicated that, given similar widths of thermal damage, a setting of 40 W was sufficient to incise the thick porcine skin while creating a cutting environment and feel most similar to a real clinical setting. The PlasmaBlade settings were selected to provide an equivalent cutting rate of the skin. All incisions were made in a single stroke, with repetitive strokes made only if necessary to ensure a full-thickness wound.

All wounds were closed with 3-0 nylon suture and covered with antibiotic ointment (MWI Veterinary Supply). Preoperative and postoperative antibiotics (Baytril, 5 mg/kg administered intramuscularly; MWI Veterinary Supply) were administered for 7 days. All wounds were inspected daily and sutures were removed on day 14.

Blood Loss Evaluation

Blood loss evaluation was performed on three animals ($n = 15$ wounds per device). A 110-mm-diameter filter paper (Schleicher & Schuell, West Chester, Pa.) was placed immediately over each incision for 60 seconds and then scanned (HP Scanjet; Hewlett Packard, Mountain View, Calf.) into JPEG digital image format. The digitized area of blood staining was quantified (in pixels) using ImageJ software (from vsbweb.nih.gov/ij/).

Scar Formation

Digital photographs of the wounds were taken immediately postoperatively and every 7 days thereafter. Scar width was measured using the ImageJ software program.

Wound Strength

After the procedure on day 42, animals were killed and all wound sites were harvested immediately to maintain all wounds in an equal postmortem state for objective comparison. A 2 × 1-cm, full-thickness strip of tissue with the incision at the midpoint was excised using a steel template. Wound burst strength was measured in pound-feet per inch as described previously[7] using a Chatillon TCD200 digital force tester (Ametek, Largo, Fla.). Briefly, the incision line was aligned within the jaws of the clamp, and progressive force at an extension rate of 2 inches per minute was applied until wound disruption.

Histologic Examination

A 1 × 0.5-cm specimen containing the incision was excised and fixed in 10% buffered formalin (VWR, West Chester, Pa.) for 24 hours and embedded in paraffin. Representative 4-μm sections were stained with hematoxylin and eosin and Masson trichrome stain. All specimens were coded and evaluated by light microscopy (Olympus BX 40 microscope with a DP70 digital camera; Olympus, Center Valley, Pa.) by a single pathologist in a blinded manner. Acute thermal injury was determined as a maximum width of the zone of coagulation necrosis using hematoxylin and eosin sections.

Immunohistochemistry

All sections were examined for T lymphocytes (CD3 M7254; Dako, Carpinteria, Calif.), macrophages (CD68 NCL-L-CD68, Novacostra, Newcastle, United Kingdom), and myofibroblasts [α-smooth muscle actin (SMA M0851; Dako)]. Sections were examined under high-power magnification (40×) and the number of cells counted by a blinded observer.

Statistical Analysis

All data are reported as mean ± SEM. Data were compared using the t test. A value of $p < 0.05$ was considered significant. No correction was made for multiple testing.

RESULTS

Instrument Operating Temperatures

The operating temperature of each instrument was measured by an infrared camera, with power settings consistent with those used during the surgical procedures performed in this study. With the tissue at room temperature (25°C), the PlasmaBlade exhibited an average operating temperature of 45°C. In contrast, the average operating temperature of the electrosurgical instrument was 241°C in cut mode and 180°C in coagulation mode (Fig. 1).

Blood Loss Evaluation

The filter paper–based bleeding analysis demonstrated an average relative area units (relative area unit = 10^5 pixels) measurement of 1.03 ± 0.27 for the PlasmaBlade versus 2.50 ± 0.32 for the scalpel ($p = 0.002$) (Fig. 2), representing a 59 percent reduction in bleeding. Electrosurgical cut and coagulation also demonstrated reduced bleeding compared with scalpel incisions (0.52 ± 0.33 and 0.29 ± 0.29 relative area unit, respectively; $p = 0.002$) (Fig. 2); however, there was no statistically significant difference compared with the PlasmaBlade ($p = 0.23$ and $p = 0.07$, respectively). This demonstrates that the PlasmaBlade significantly reduces bleeding compared with the scalpel, and is comparable to traditional electrosurgical devices.

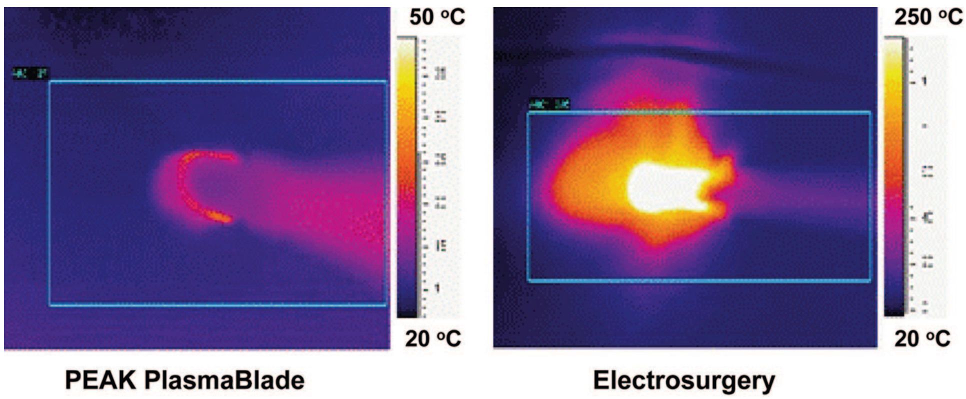

Fig. 1. Temperature maps of the PlasmaBlade and electrosurgical device in the cut mode, captured by the infrared camera. The PlasmaBlade average temperature was 45°C, whereas that of electrosurgery was 241°C.

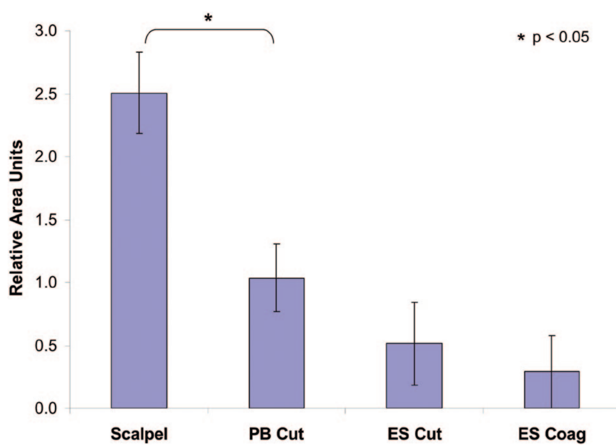

Fig. 2. Bleeding from incisions produced by the scalpel, PlasmaBlade (*PB*), and electrosurgical (*ES*) device in cut and coagulation modes, over 1 minute, measured as an area of blood staining the filter paper.

Zone of Coagulation Necrosis

The zone of thermal coagulation necrosis in PlasmaBlade incisions (66 ± 5 μm) was significantly narrower than in electrosurgical cut or coagulation incisions (456 ± 35 μm and 615 ± 22 μm, respectively; $p < 0.0001$) (Figs. 3 and 4, *a*). This observation suggests that the PlasmaBlade may be used in closer proximity to adjacent fragile structures, such as nerves and blood vessels, with less risk of collateral injury.

Inflammatory Markers

At 1 week after surgery, T-cell counts based on $CD3^+$ staining were increased in all samples (Fig. 5). By week 3, the PlasmaBlade incisions contained 46 percent fewer T cells than scalpel incisions (9.7 ± 3.7 cells/high-power field versus 18.0 ± 3.7 cells/high-power field; $p < 0.04$), 59 percent fewer T cells than in the electrosurgical cut incisions, and 56 percent fewer T cells than in the electrosurgical coagulation incisions (23.7 cells/high-power field and 22.3 cells/high-power field, respectively; $p < 0.05$). At 6 weeks, the incisions created by the PlasmaBlade contained 52 percent fewer T cells than scalpel incisions (4.7 ± 1.7 cells/high-power field versus 9.7 ± 1.2 cells/high-power field; $p < 0.04$) (Fig. 5) and 66 percent and 72 percent fewer T cells than the electrosurgical cut and coagulation incisions (13.7 ± 4.4 cells/high-power field and 17.1 ± 3.2 cells/high-power field, respectively; $p < 0.03$). This suggests the PlasmaBlade causes less inflammation compared with all other modalities.

Macrophages identified as $CD68^+$ cells were highest at 1 week (Fig. 6), with the lowest number seen in PlasmaBlade incisions, which contained 38 percent fewer macrophages than scalpel incisions, 41 percent fewer macrophages than electrosurgical cut incisions, and 32 percent fewer macrophages than electrosurgical coagulation incisions (19.3 ± 5.5 cells/high-power field versus 31.3 ± 5.7, 32.7 ± 7.3, and 28.5 ± 7.3 cells/high-power field, respectively; $p < 0.05$). By week 2, the electrosurgical cut incisions had approximately 50 percent more macrophages compared with all other modalities (32.7 ± 7.3 cells/high-power field versus 16.5 ± 6.9, 13.7 ± 6.6, and 16.3 ± 6.6 cells/high-power field for PlasmaBlade, scalpel, and electrosurgical coagulation, respectively; $p < 0.05$). However, at week 6, the electrosurgical coagulation incisions had significantly more macrophages than the other modalities (12.5 ± 5.8 cells/high-power field versus 1.2 ± 0.4, 2.8 ± 2.3, and 1.0 ± 1.0 cells/high-power field for Plasma-

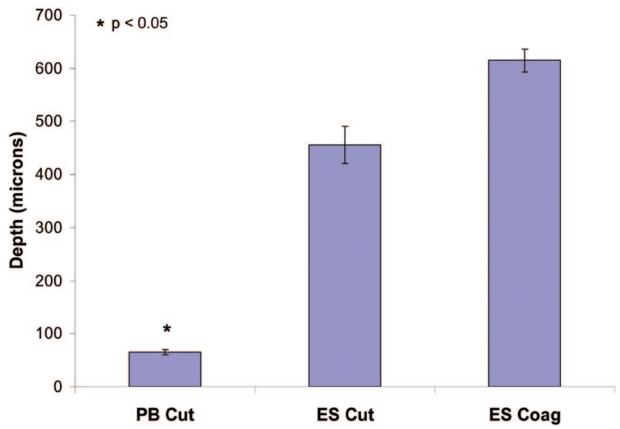

Fig. 3. Width of the acute thermal injury zone created by the PlasmaBlade (66 ± 5 μm), electrosurgical cut mode (456 ± 35 μm), and electrosurgical coagulation mode (615 ± 22 μm).

Blade, scalpel, and electrosurgical cut, respectively; $p < 0.05$). These data further suggest that during the first and second weeks of wound healing, the PlasmaBlade induces significantly less inflammation than the electrosurgical device and possibly even the scalpel. Although the inflammatory response appeared to have stabilized among all modalities by week 3, a higher prevalence of macrophages remained up to 6 weeks in electrosurgical coagulation wounds, indicating a persistent, ongoing inflammatory response likely attributable to the presence of necrotic debris in the wound site.

Scalpel incisions showed the lowest levels of smooth muscle actin–positive myofibroblasts throughout the 6-week time period (Fig. 7). The PlasmaBlade and scalpel incisions showed a similar prevalence of myofibroblasts at the 1-, 3-, and 6-week time points, with no statistically significant difference at any time point (19.3 ± 10.6 versus 18.5 ± 10.6 cells/high-power field at 1 week, 9.7 ± 1.5 versus 5.3 ± 2.0 cells/high-power field at 3 weeks, and 1.7 ± 0.3 versus 1.3 ± 0.7 cells/high-power field at 6 weeks for PlasmaBlade and scalpel, respectively; $p > 0.15$). However, both electrosurgical modes induced significantly more myofibroblasts throughout the entire time period, with the greatest numbers seen at 3 weeks after surgery, when PlasmaBlade incisions had only a fraction of myofibroblasts compared with electrosurgical cut (43 percent; 9.7 ± 1.5 versus 22.7 ± 12.0 cells/high-power field; $p < 0.001$) and electrosurgical coagulation (29 percent; 9.7 ± 1.5 versus 38.3 ± 1.7 cells/high-power field; $p < 0.001$) incisions, respectively. By week 6, the myofibroblast cell numbers normalized except for electrosurgical coagulation, although the difference was not statistically significant. The increased presence of myofibroblasts in the electrosurgical incisions offers a potential explanation for the poor cosmesis seen in healed electrosurgical wounds.

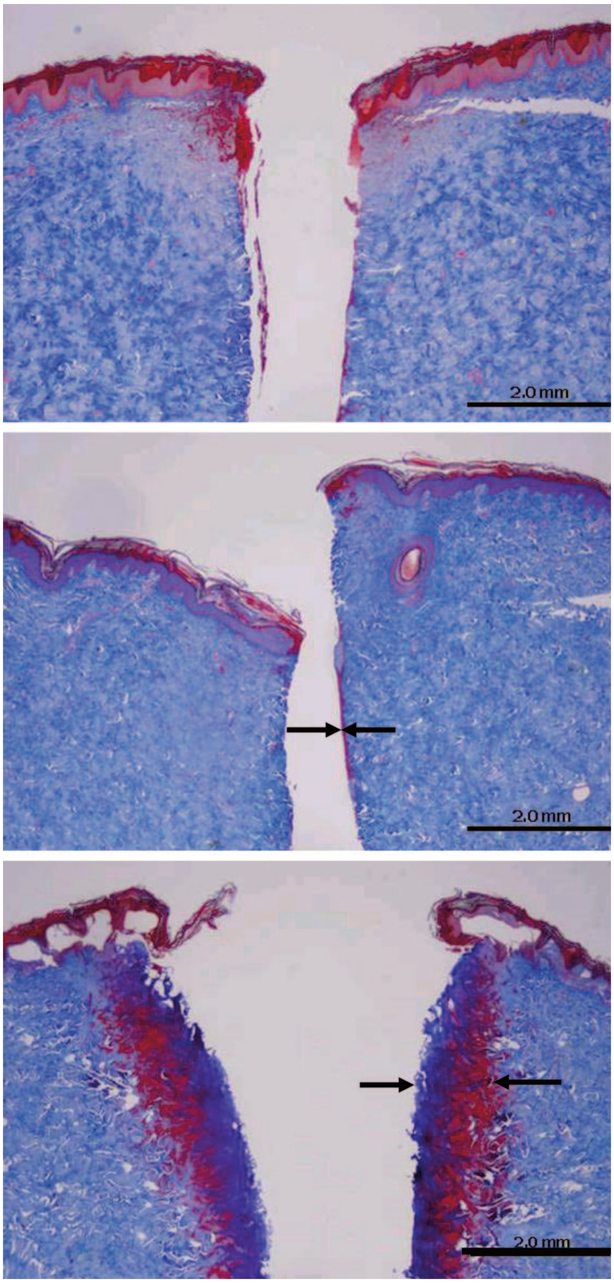

Fig. 4. Acute histology of the skin incisions produced by (*above*) scalpel, (*center*) PlasmaBlade, and (*below*) electrosurgical cut modes. *Arrows* indicate the zone of coagulation necrosis. Scale bar = 2.0 mm.

Scar Formation

Measurement of the scar width at each time point showed no significant difference between

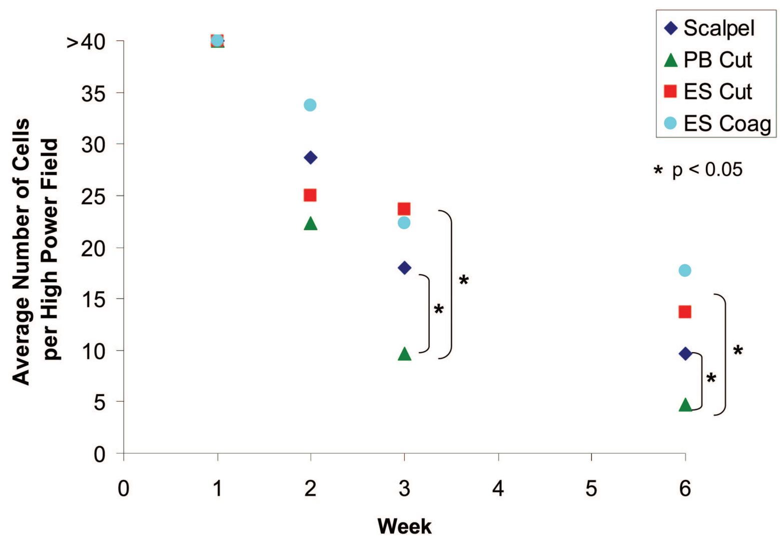

Fig. 5. Number of $CD3^{+}$ lymphocytes in the wounds produced by the four instruments at 1, 2, 3, and 6 weeks after surgery. PlasmaBlade incisions exhibited the least amount of inflammation. *PB*, PlasmaBlade; *ES*, electrosurgical; *Coag*, coagulation.

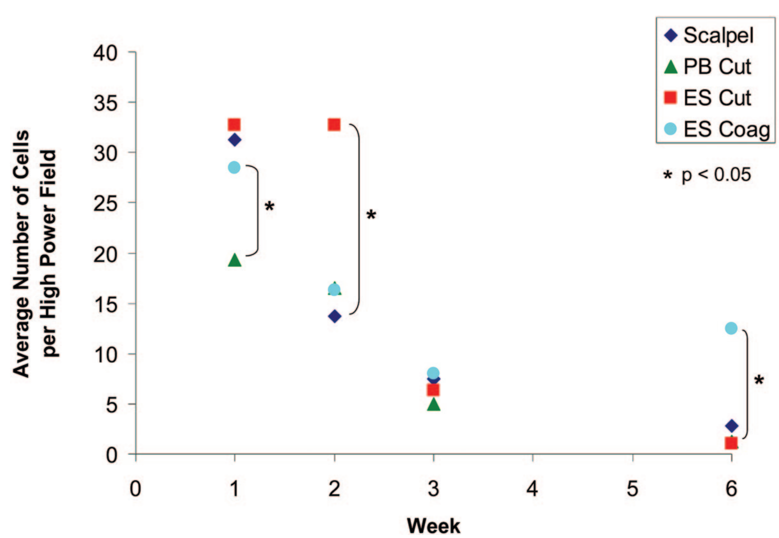

Fig. 6. Number of macrophages ($CD68^{+}$ cells) in the wounds at 1, 2, 3, and 6 weeks after surgery. The significant presence of macrophages in the electrosurgical coagulation wounds at 6 weeks suggests continued inflammation. *PB*, PlasmaBlade; *ES*, electrosurgical; *Coag*, coagulation.

PlasmaBlade and scalpel incisions (p = 0.25 to 0.84) (Figs. 8–10, *a*), with both much narrower than the electrosurgical scars. At 1 week, the PlasmaBlade scar width was 24 percent and 22 percent the width of the electrosurgical scars (0.85 ± 0.17 mm versus 3.50 ± 0.76 mm for electrosurgical cut and 3.77 ± 0.39 mm for electrosurgical coagulation; p = 0.0021 and p < 0.0001, respectively). Similarly, at 2 weeks, the PlasmaBlade scar width was 44 percent and 32 percent the width of the electrosurgical scars (1.02 ± 0.30 mm versus 2.33 ± 0.33 mm for cut and 3.17 ± 0.41 mm for coagulation; p = 0.03 and p = 0.0017, respectively). This trend continued at 3 weeks, when the PlasmaBlade scar width was 27 percent and 18 percent the width of the electrosurgical scars (0.59 ± 0.10 mm versus 2.17 ± 0.4 mm for cut and 3.27 ± 0.21 mm for coagulation; p = 0.0018 and p < 0.0001,

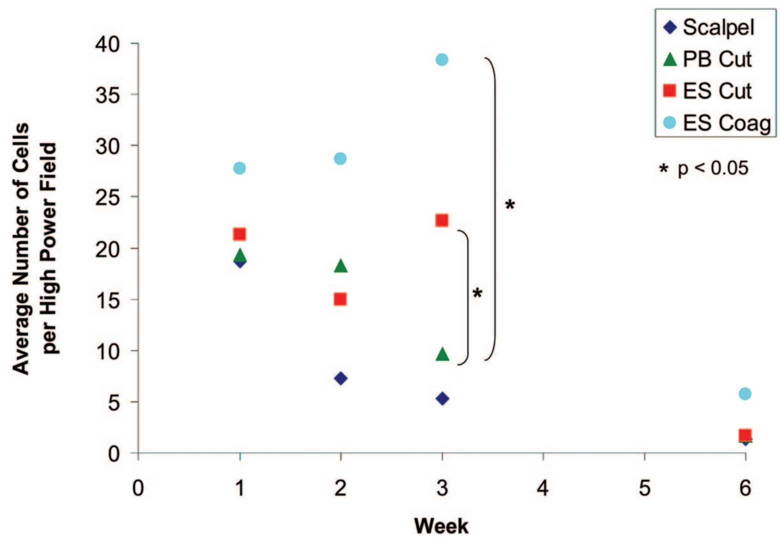

Fig. 7. Number of myofibroblasts (smooth muscle actin–positive cells) in the wounds at 1, 2, 3, and 6 weeks after surgery. *PB*, PlasmaBlade; *ES*, electrosurgical; *Coag*, coagulation.

respectively). Finally, at 6 weeks, the PlasmaBlade scar width was 25 percent and 16 percent the width of the electrosurgical scars (0.38 ± 0.06 mm versus 1.50 ± 0.29 mm for cut and 2.33 ± 0.20 mm for coagulation; $p = 0.001$ and $p < 0.0001$, respectively) (Figs. 8–10, *b*). Visual evaluation of electrosurgical incisions demonstrated heavy scarring and poor cosmesis, whereas PlasmaBlade and scalpel incisions healed with minimal scarring and an improved aesthetic outcome (Figs. 8–10, *c*).

Wound Burst Strength Evaluation

Scalpel and PlasmaBlade incisions exhibited greater tensile strength compared with electrosurgical incisions at all time points (Fig. 11),

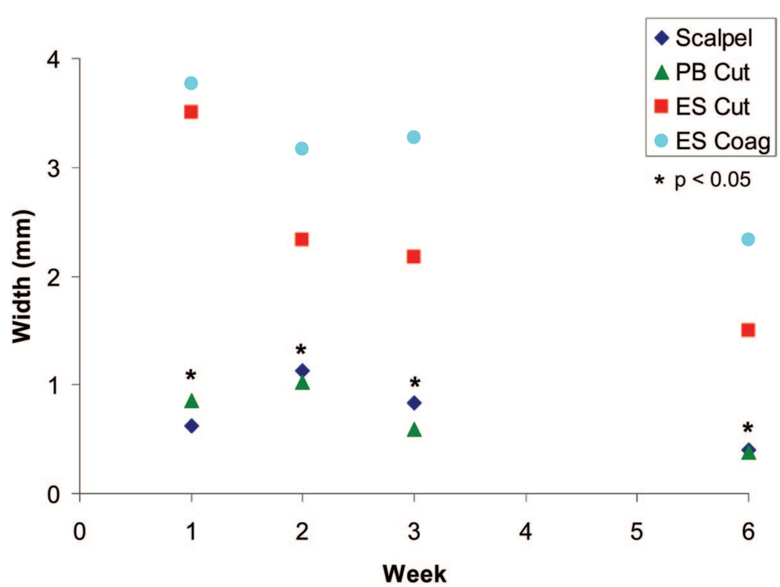

Fig. 8. Histologic measurement of wound scar width. At any time point, there was no statistically significant difference between the PlasmaBlade and scalpel wounds, whereas both were much smaller than electrosurgical cut and electrosurgical coagulation wounds. *PB*, PlasmaBlade; *ES*, electrosurgical; *Coag*, coagulation.

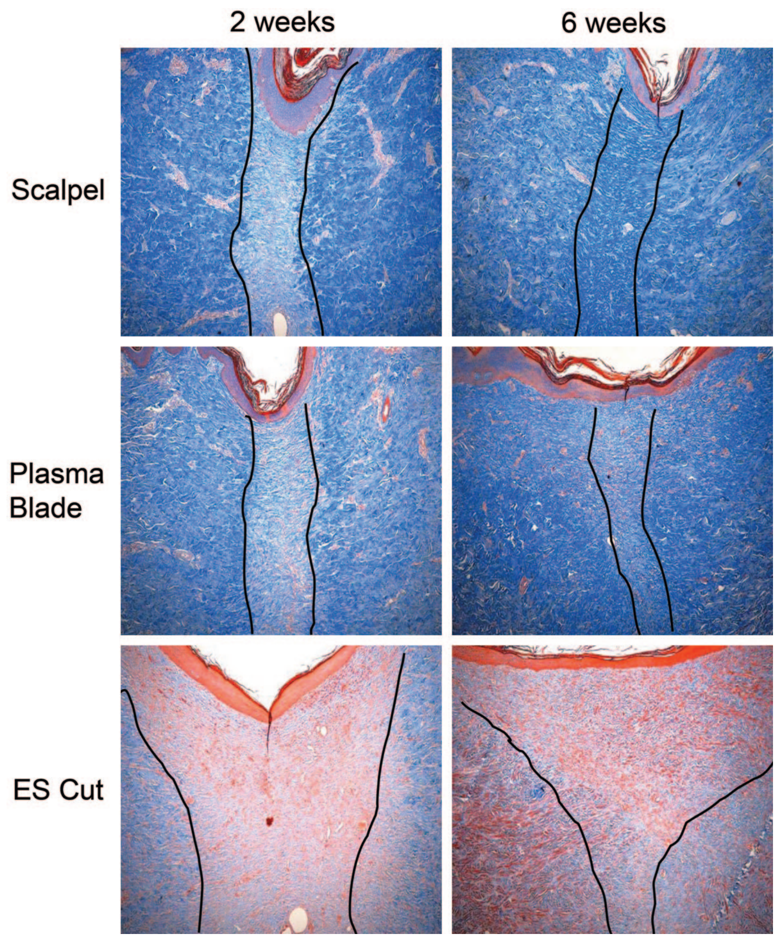

Fig. 9. Histology of the wounds at 1, 2, and 6 weeks after incision. Scalpel and PlasmaBlade wounds appear healed with normal tissue morphology. In contrast, the electrosurgical cut wounds are wider and contain significantly more scar tissue.

although it was not until week 3 that statistical significance was achieved compared with the electrosurgical coagulation incisions (76.9 ± 14.9 lb-ft/in for PlasmaBlade versus 20.1 ± 2.9 lb-ft/in for electrosurgical coagulation; $p = 0.006$) and approached compared with electrosurgical cut incisions (32.6 ± 1.6 lb-ft/in; $p = 0.07$). PlasmaBlade incisions demonstrated similar burst strength compared with scalpel incisions at 6 weeks (154.4 ± 12.3 lb-ft/in versus 165.5 ± 13.5 lb-ft/in; $p = 0.56$). In contrast, both electrosurgical modes were markedly weaker, withstanding only 59.6 ± 20.9 lb-ft/in (cut) and 55.5 ± 8.8 lb-ft/in (coagulation) at 6 weeks ($p = 0.005$ and $p = 0.0002$, respectively). This further supports our conclusion that the PlasmaBlade offers superior wound-healing and strength characteristics compared with conventional electrosurgical incisions.

DISCUSSION

Traditionally, the scalpel has been considered the surgical cutting tool of choice because of its precision, control, preservation of tissue integrity, and superior associated wound healing. However, its primary disadvantage is bleeding; consequently, numerous electrosurgical devices have been developed to provide hemostasis. Although hemostasis is improved, electrosurgical devices suffer from thermal damage to surrounding tissues, inferior wound healing, and poor cosmesis,[4,5,7,9,10,12] which limit their realm of applications.

In this study, we evaluated the PlasmaBlade, a new electrosurgical device that produces pulsed plasma–mediated discharges at the edge of an insulated electrode to allow precise dissection of tissue.[14] Our current study corroborates previous

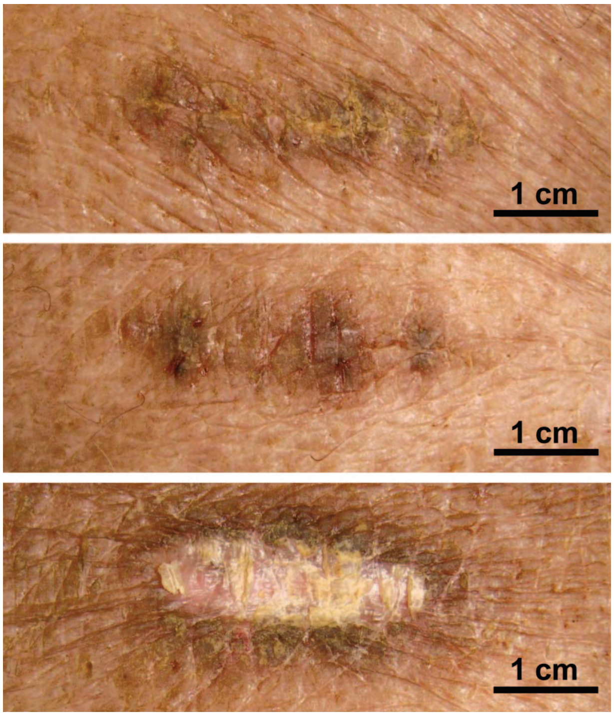

Fig. 10. Clinical appearance of the wounds 6 weeks after surgery. Scalpel (*above*) and PlasmaBlade (*center*) wounds are very similar, unlike the much wider wounds of the electrosurgical cut mode (*below*), which exhibited profound scarring.

findings demonstrating precise tissue dissection in rabbit, bovine, and human retinas and lens capsules.[13,16–21] This is the first study to examine pulsed plasma–mediated electrosurgical technology on cutaneous wound healing. The PlasmaBlade exhibited a 59 percent reduction in bleeding compared with scalpel wounds, which was comparable to bleeding seen with conventional electrosurgical tools. Given the PlasmaBlade's lower blade temperature and reduced thermal damage to adjacent tissues, this result suggests that the high operating temperatures and deep thermal coagulum associated with electrosurgery are not always essential for hemostasis. One possible mechanism of the hemostasis produced by the PlasmaBlade may be a nonthermal vasoconstrictive and thrombotic effect[22]; however, further study of this phenomenon is necessary.

Our observation of the greater infiltration by $CD3^+$ T lymphocytes during the course of healing in the electrosurgical group corroborates previous reports of abnormal inflammatory response correlating with reduced wound burst strength.[4,5,7,10,12] The burst strength of the incisions created by the PlasmaBlade, however, were similar to those of the scalpel and three times stronger than electrosurgical incisions. Such dramatic differences are most likely attributable to the deeper zone of thermal necrosis with electrosurgery. This results in a protracted inflammatory response necessary to clear greater amounts of necrotic tissue that interferes with reepithelialization and collagen formation. Interestingly, the levels of T lymphocytes and macrophages were lower in the PlasmaBlade group than in the scalpel group. The reason for this is unclear, but perhaps the reduction in bleeding and applied pressure during cutting by the PlasmaBlade further limits the level of inflammation present. Future studies will be needed to more fully explain these observations.[23–25]

Reduced thermal injury and improved wound histology and strength correlated strongly with the visual appearance of the scars. This is again likely attributable to reduced levels of inflammation, leading to more efficient epithelialization, reduced macrophage cytokine production, decreased myofibroblast proliferation, reduced transforming growth factor-β production, and ultimately improved scarring and comesis.[26–29] Visual assessment of the scars at 6 weeks showed dramatically less scarring with PlasmaBlade and scalpel incisions compared with the hypertrophic scarring observed in the electrosurgical group. We are not aware of other reports comparing scarring caused by electrosurgery, scalpels, or other surgical technologies, but we believe it is an important parameter for patient satisfaction, especially in the field of aesthetic and reconstructive surgery.

In addition, a number of anecdotal observations suggest additional benefits of the PlasmaBlade. We noted that incisions made with the PlasmaBlade required much less pressure than traditional scalpels; thus, it was not necessary to maintain constant tension on the skin when making the incision. This may reduce chances of slippage, tearing, and unintentional extension of incisions.[21] We also noted that the PlasmaBlade was less adherent to the wound edges, likely because of lower operating temperatures. Furthermore, the PlasmaBlade maintained its cutting effectiveness and hemostatic ability even when submerged in liquefied adipose tissue or blood, unlike electrosurgical cutting tools. Finally, the PlasmaBlade was noted to produce little to no surgical smoke, which is noxious, obscures the visual field, and has been shown to contain infectious viruses.[30]

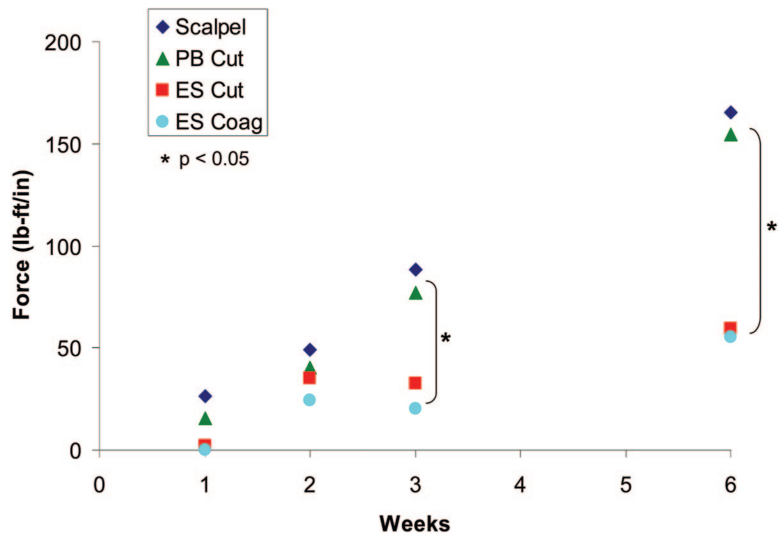

Fig. 11. Burst strength of the wounds produced by the four instruments at 1, 2, 3, and 6 weeks after surgery. At all time points, there was no statistically significant difference between the PlasmaBlade and scalpel, whereas the electrosurgical wounds were much weaker. At 6 weeks, the PlasmaBlade wounds were approximately three times stronger than those made by electrosurgery. *PB*, PlasmaBlade; *ES*, electrosurgical; *Coag*, coagulation.

CONCLUSIONS

In summary, we demonstrate that the PlasmaBlade provides efficient cutting of skin, with a superior wound-healing profile, comparable to that of the traditional scalpel but with significantly less bleeding. PlasmaBlade incisions heal in a manner similar to that of scalpel incisions but superior to that of electrosurgical incisions with respect to inflammation, wound strength, and scarring. These results suggest that the PlasmaBlade has tremendous potential in surgical fields where electrosurgery is not used extensively, including plastic and reconstructive surgery; cardiothoracic, gynecologic, vascular, and laparoscopic surgery; and neurosurgery.

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