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Gel reduces heat damage in laser, RF skin incisions

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Both high-fluence, brief-pulsed carbon dioxide (CO_2) lasers and ultrahigh-frequency radio waves can develop fine cutaneous incisions while providing variable degrees of hemostasis. Microsecond pulses of a CO_2 laser vaporize intracellular water (100° C) while coagulating intracellular proteins (60° C). This permits epidermal lysis by way of an ablation front followed by rapid tissue cooling.

The dermis is mainly composed of an extracellular matrix composed largely of collagen. The CO_2 laser incises the dermis by way of pulse stacking. There is progressively less vaporization and more coagulation as the CO_2 laser cuts deeper into the dermis. Tissue cooling becomes slower, with increasing thermal diffusion into the incised margins. The benefit of lateral heat diffusion is hemostasis. The drawback is increasing thermal injury, which delays early wound repair and wound maturation.

Lateral thermal injury

Ultrahigh-frequency radio waves delivered on contact via a fine tungsten active electrode are directed through the skin toward a passive electrode (antennae). The natural resistance of the tissues results in volatilization at the tip of the active electrode. The deep dermal wound margins do not take on the yellow hue associated with coagulative necrosis.

Incisions made via ultrahigh-frequency radio waves histopathologically demonstrate less lateral marginal heat damage than incisions developed with a pulsed CO_2 laser. Skin incisions with a thermal component result in some degree of coagulative necrosis and eschar formation, which acts as a mechanical barrier impeding the onset of re-epithelialization and dermal remodeling. Wound repair cannot proceed until monocytes debride the tissue margins.

Both the CO_2 laser and ultrahigh-frequency radio waves can develop incisions in normally hydrated skin. However, if the skin is dehydrated there is less vaporization and more burn injury at the incision margins. Skin that is edematous or expanded by microvascular dilation requires more energy to be cut with these surgical modalities. This may result in increasing lateral thermal injury.

Tissue cooling

Various lasers used in dermatologic surgery can blister the epidermis, particularly in deeply pigmented patients. This is because the targeted chromophores (melanin or hemoglobin) are present adjacent to the targeted lesion.

The epidermis can be protected from burns by preoperative, intraoperative or postoperative tissue cooling. Various modalities to cool the epidermis include active cooling (a cryogen unit), spray cooling and passive cooling (ice-packs).

A microclysmic cooling gel (Humatrix, Care-Tech Laboratories) can be used prior to or immediately following laser surgery.

Applied at room temperature, it cools the epidermis within 4 minutes of application and lowers the surface temperature of the skin by 8° to 10° F. It modulates the osmotic pressure in the epidermis by the timed release of moisture. Heat reduction is achieved by the gel actively drawing heat from the tissue and releasing it into the surrounding air. The molecular size of this gel facilitates intracellular penetration.

Application of the cooling gel prior to either CO_2 laser or radio-frequency ablative incisions may blunt thermal diffusion into the incised margins and base. Pre-cooling may constrict the cutaneous microcirculation, thereby reducing tissue density and required incisional power density.

Lateral thermal damage comparison

We compared histopathologically the extent of lateral thermal damage in upper eyelid skin incisions performed with either a CO_2 laser or radio frequency waves in skin chilled using Humatrix to a contralateral noncooled control incision. The skin incisions were performed bilaterally with either a CO_2 laser (UltraPulse, Lumenis) or with 4-mHz ultrahigh-frequency radio waves (Surgitron, Ellman International).

On the gel-treated side, the gel was applied to a 4-mm height and remained on the skin for 4 minutes immediately before and after creation of the skin incision. Each incision was centered in the redundant upper eyelid skin before excision of the myocutaneous flap in two patients