Thermal cautery of the cornea for treatment of spontaneous chronic corneal epithelial defects in dogs and horses

Ellison Bentley, DVM, DACVO, and Christopher J. Murphy, DVM, PhD, DACVO

In dogs, spontaneous chronic corneal epithelial defects (SCCEDs) are chronic erosions of the cornea that fail to undergo normal epithelial wound healing. These defects are seen most commonly in middle-aged (ie, 6- to 9-year-old) dogs and can occur in dogs of any breed. Clinically, SCCEDs are characterized by a surrounding area of epithelium that is not adherent to the underlying corneal stroma. A lack of treatment or inadequate treatment can result in persistence of SCCEDs for months or years.

A similar clinical entity in horses has been reported several times. Although the clinical appearance and long-standing history are similar to findings in dogs with SCCEDs, extensive histologic and ultrastructural studies have not been performed. Thus, it is not clear whether lesions in horses are the same as those in dogs. Nevertheless, SCCED is a clinical diagnosis in dogs, and treatments that have been reported to be successful in dogs with SCCEDs (eg, epithelial debridement and superficial keratectomy) have also been reported to be successful in horses with similar lesions.

Typically, topical antimicrobial treatment of SCCEDs is ineffective, and although topical treatment with trophic factors has met with greater success, defects do not resolve in 20% to 30% of dogs treated with trophic factors. Commonly used surgical options include epithelial debridement, anterior stromal puncture or grid keratotomy, and superficial keratectomy; however, success rates vary. Contact lenses have been used alone and in conjunction with other treatments.

Spontaneous chronic corneal epithelial defects in dogs have been the focus of several recent reports. Histologically, SCCEDs in affected dogs consist of an area of epithelial dysmaturation and a rim of nonadherent epithelial cells surrounding denuded stroma. Basement membrane components, including laminin, collagen IV, and collagen VII, are typically absent from the stromal surface in the area of the erosion; however, fibronectin is almost always present, and the lack of a basement membrane has been confirmed by means of electron microscopy. The area of the defect contains an abnormal, superficial, hyalinized stromal lamina, and on electron microscopy, an amorphous substance is seen admixed with the stromal collagen fibers. Immunohistochemical staining reveals a dense, abnormal nerve plexus composed of substance P and calcitonin gene-related peptide immunoreactive fibers surrounding the defect. The peripheral corneal epithelium and its underlying stroma are morphologically and immunohistochemically normal in dogs with SCCEDs, suggesting that these dogs do not have primary basement membrane dystrophy. In addition, clinically normal dogs that undergo weekly epithelial debridement of the cornea do not develop the same stromal and basement membrane changes, suggesting that alterations in the corneal stroma observed in dogs with SCCEDs do not develop simply as a consequence of the persistent epithelial defect but are likely a key element in the pathogenesis of SCCEDs. We believe that the stromal changes in dogs with SCCEDs may act as a barrier to the formation of adhesion complexes between epithelial cells and the underlying stroma and that this may help explain why treatments that alter or remove this abnormal stroma, such as superficial keratectomy, are more effective than those that only minimally affect the stroma.

Thermal cautery has been shown to alter the normal superficial portion of the stroma while allowing epithelial adhesion in dogs and people with recurrent erosions associated with bullous keratopathy. Thus, we speculate that thermal cautery, by altering the abnormal hyalinized stromal lamina associated with SCCED, would be an effective treatment for SCCEDs. The purposes of the present report were to describe a technique for thermal cautery treatment of dogs and horses with SCCEDs and report results of this procedure in 8 dogs and 2 horses.

Description of the Technique

Anxious dogs and dogs that were difficult to restrain were sedated with butorphanol (0.2 to 0.4 mg/kg [0.09 to 0.18 mg/lb], IM) and acepromazine (0.05 mg/kg [0.023 mg/lb], IM) or with midazolam (0.1 mg/kg [0.045 mg/lb], IM) and hydromorphone (0.2 mg/kg, IM). The 2 horses were sedated with xylazine (75 mg/kg [34 mg/lb], IV), and auriculopalpebral nerve blocks were administered. Four to 6 drops of 0.5% proparacaine hydrochloride were administered topically over 2 minutes, and dogs were then manually restrained in sternal or lateral recumbency. Before the procedure was begun, efforts were made to ensure that the animal's head was fully restrained. Cotton-tip applicators or No. 15 blades were used to remove any frankly loose epithelial cells surrounding the defect; but aggressive debridement of the epithelium was not attempted. A sterile, disposable, handheld thermal cautery unit was then used to make multiple, small (≤ 1 mm in diameter), superficial burns throughout the affected area (Fig 1). All procedures were performed with a 2.5X operating loupe so that subtle alterations in the most superficial aspect of the corneal stroma could be seen.
The tip of the cautery unit was usually crimped with hemostats to create a finer tip for this procedure. In addition, use of a new cautery unit was avoided. Rather, cautery units that had previously been used multiple (3 to 6) times for unrelated surgical procedures and had been resterilized were used, as it was thought that the diminished thermal output of used cautery units provided finer control while performing thermal cautery, making it less likely that burns would be too deep. The tip of the cautery unit was allowed to heat and then gently moved toward the cornea until it just touched or lay just above the exposed stroma, depending on the amount of heat generated by the cautery tip. If the tip of the cautery unit became red hot, the activation button was released and the tip was allowed to cool slightly before use. The cautery unit was moved toward the cornea just until the slightest degree of contraction of the collagen fibrils was observed. If the tip of the cautery was quite hot, it was not necessary to actually contact the corneal tissue with the cautery to achieve the desired effect. After the stromal bed of the defect was treated, a rim of epithelialized cornea that extended approximately 1 mm around the denuded stroma was also subjected to thermal cautery because the stromal acellular zone has been shown to extend for a short distance under the adjacent attached epithelium, and epithelial dysmaturation has been shown adjacent to the exposed stroma. After thermal cautery was completed, a therapeutic, soft-bandage contact lens was placed, and in the dogs, an Elizabethan collar was applied. Broad-spectrum antimicrobial solutions (neomycin-polymyxin-gramicidin, gentamicin, or tobramycin) were applied every 8 hours until healing was evidenced by lack of retention of fluorescein stain.

Results
The thermal cautery technique was performed in 9 eyes of 8 dogs and 2 eyes of 2 horses. In all animals, the diagnosis of SCCED had been made on the basis of persistence of a corneal epithelial defect for at least 3 weeks without appreciable progress toward resolution,
an absence of any underlying stromal loss, a lack of any indication of sepsis, and an inability to identify any underlying reason for persistence of the erosion. Mean age of the dogs was 9.7 years (range, 7 to 15 years). Six were spayed females, 1 was a castrated male, and 1 was a sexually intact male. There were 2 mixed-breed dogs, 2 Golden Retrievers, 2 Boxers, a Labrador Retriever, and a Boston Terrier. Mean duration of the erosion prior to thermal cautery was 5.4 weeks (range, 3 to 12 weeks). Previous treatments that had been attempted included topical administration of antimicrobials (n = 3), epithelial debridement (3), contact lens placement (1), and topical application of growth factors (2). Six of the 8 dogs were sedated for thermal cautery of the defect; in the remaining 2, only topical anesthesia was used. A contact lens was inserted after the procedure in 8 of the 9 eyes. A neomycin-polymyxin-gramicidin ophthalmic solution was used after thermal cautery in 8 eyes, and a gentamicin ophthalmic solution was used in 1. Mean time to healing was 2.1 weeks (range, 2 to 3 weeks). In all dogs, the defect healed with minimal scarring. Animals were followed up for 1 month to 3 years after surgery (Fig 2).

The horses were a 7-year-old castrated male Quarter Horse and a 2-year-old female Percheron. Both horses had superficial erosions; erosions had been present for 3 and 4 weeks, respectively. Prior to thermal cautery, the horses had been unsuccessfully treated with epithelial debridement and topical antimicrobial administration. Contact lenses were not placed after surgery. One horse was treated with neomycin-polymyxin-gramicidin ophthalmic ointment twice daily after surgery; the other was treated with tobramycin ointment twice daily until healing was evident. The ulcer in 1 horse healed in 1 week; the ulcer in the second horse healed in 2 weeks.

**Discussion**

The mechanism by which thermal cautery resulted in resolution of SSCEDs in the dogs and horses in the present report is not clear. Acute thermal burns cause disruption of the stromal lamellae through contraction of collagen fibrils and keratocyte injury and death.35 Fibroblasts then migrate into the superficial portion of the stroma.15 Previous studies10,16 have demonstrated the formation of a distinct superficial, hyalinized stromal lamina in dogs with SSCED, and it is this tissue that is altered with the thermal cautery technique described in the present report. A report17 in horses also revealed distinct stromal abnormalities in the area of nonhealing erosions. The successful outcome in the animals described in the present report further supports the suggestion that abnormal stromal elements, rather than primary epithelial or basement membrane abnormalities, represent the primary underlying defect in dogs with SSCEDs. Although similar clinically, horses with SSCEDs may have different ultrastructural or biochemical alterations than do dogs; however, the similar response to treatment in the 2 horses in this study suggests a common underlying stromal component.

The term thermokeratoplasty has previously been used in veterinary medicine to describe the technique of using thermal energy to create a layer of subepithelial scar tissue in the treatment of bullous keratopathy.11,13 This procedure was originally described as diathermy of Bowman's membrane,15 as the term Bowman's membrane refers to a specialized aspect of the most superficial portion of the stroma in humans, birds, and a limited number of other animals, and subsequently was referred to as electrocautery of Bowman's membrane.18 In more recent years, the term thermokeratoplasty has been used to describe the application of laser, microwave, or thermal energy to alter the corneal curvature and change the refractive state of the eye.14 Thus, we have chosen to use the term thermal cautery of the cornea as a more accurate description of the procedure described in the present report and to avoid introducing confusion between the veterinary and physician-based medical literature.

Spontaneous chronic corneal epithelial defects can be a frustrating problem in dogs, as they are often unresponsive to treatment. Results in the limited number of dogs in the present report suggest that thermal cautery may be a reasonable alternative to previously described, more invasive procedures and treatments. In particular, the fact that defects in all 11 eyes in the present report healed suggests that thermal cautery may prove to be as successful as superficial keratectomy for the treatment of SSCED.5 In addition, whereas thermal cautery required the use only of sedation and topical anesthesia in these dogs and horses, superficial keratectomy requires the use of general anesthesia. Also, thermal cautery appeared to result in less scarring, compared with our experiences in dogs that have undergone superficial keratectomy, and would be expected to disrupt the corneal curvature to a lesser extent. Therefore, it may be less likely to be associated with visual degradation. However, a clinical trial with a much larger number of dogs is needed to determine the true success rate for thermal cautery.

Severe complications have been associated with thermal cautery. In humans, for instance, complications associated with thermal cautery include stromal scarring, stromal necrosis, iritis, hypopyon, and corneal neovascularization.12,21 Complications identified in dogs undergoing thermal cautery for treatment of epithelial defects secondary to bullous keratopathy include stromal fibrosis and corneal neovascularization.13,14 The use of cautery in the treatment of epithelial defects associated with bullous keratopathy, however, requires much more aggressive treatment to create a lamina of scar tissue in the superficial portion of the stroma. The degree of corneal reaction seen in the treatment of bullous keratopathy would not be anticipated with the much milder application of cautery used for the treatment of SSCEDs as described in the present report. As complications and scarring may be more severe with thermal cautery than with anterior stromal puncture or grid keratotomy, thermal cautery should be reserved for those dogs that do not respond to other more conventional treatments. We also strongly recommend that the procedure be practiced on cadaver eyes prior to use in clinical patients. Although we were able to perform the procedure without general anesthesia in the dogs described in the present
Finally, because this procedure requires skill with microsurgical techniques, a familiarity with working with magnification, and full knowledge of the reaction of the cornea to surgical intervention, individuals without the necessary training should consider referring affected animals to a veterinary ophthalmologist for thermal cautery treatment.

References