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Clinical Features and Outcomes of Superficial Keratectomy and Conjunctival Advancement Hood Flap in Three Dogs with Different Extents of Corneal Edema

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Abstract : Three dogs with different extents of corneal edema were presented to the Dana Animal Hospital Eye Center. The dogs (3 eyes) were diagnosed with corneal endothelial degeneration with clinical signs of corneal edema, conjunctival hyperemia, and mild blepharospasm through a full ophthalmic examination. For the treatment of corneal edema, superficial keratectomy using a crescent microsurgical knife was performed, and a conjunctival advancement hood flap was applied to the stromal defects. In two cases where corneal edema and opacity were observed only in a part of the cornea, corneal edema was reduced and did not progress to other parts of the cornea and corneal transparency and vision were also well-maintained during the follow-up on days 349 and 231 after the surgery. In a case where the whole cornea was edematous and cloudy, corneal edema and opacity had not clearly improved at the last follow-up on day 275 after the surgery. In conclusion, SKCAHF relieved corneal edema and improved vision, and the prognosis tended to be better when there was less corneal edema caused by CED.

Key words : conjunctival hood flap, cornea, corneal edema, dog, superficial keratectomy.

Introduction

Corneal edema in dogs is known to be caused by excessive accumulation of fluid in the corneal stroma due to damage or dysfunction of the corneal epithelium or endothelium (11,14). This can lead to bullae formation, loss of corneal transparency, corneal ulcer, corneal neovascularization, pigmentation, corneal perforation, and even vision loss (11,16). The causes inducing corneal edema include glaucoma, anterior uveitis, corneal ulcer, anterior lens luxation, toxic damage or trauma to the endothelium, and endothelial degeneration or dystrophy (6,11,14).

Corneal edema due to corneal endothelial degeneration (CED), similar to Fuchs' endothelial dystrophy in humans, occurs frequently in Chihuahua, dachshunds, poodles, and Boston terriers (1,6,11,13). Corneal edema following CED frequently begins in the temporal paraxial region and spreads throughout the cornea (6,11,16). During the early stage of the disease, topical application of hyperosmotic agent (5% sodium chloride ointment) can be attempted (10,11,16). However, surgical treatments, such as thermokeratoplasty (TKP) using multifocal thermal cauterization on the edematous cornea (5,11,12), single superficial keratectomy (3), superficial keratectomy combined with conjunctival advancement hood flap (SKCAHF) (8), penetrating keratoplasty (1), endothelial keratoplasty (2), and corneal collagen cross-linking technique using riboflavin and UV-A light (15) have been performed during the advanced stages in human and veterinary ophthalmology.

The advantages of SKCAHF are as follows: superficial keratectomy can reduce corneal edema significantly by removing unnecessary corneal stroma and the conjunctival flap not only serves as tectonic support for stromal defects, but also reduces the corneal endothelial workload by continuously draining the stromal fluid after surgery (8,11). Horikawa et al. reported owner-reported improved vision and reduced cloudiness after this surgical method (8).

The purpose of this case report was to describe the application of SKCAHF for the treatment of corneal edema in three dogs and compare its clinical features and outcomes of this intervention according to the different stages of corneal edema.

Case Reports

Case 1 and Case 2 (Corneal edema lesser than half of the entire area of the cornea)

An 8-year-old spayed female Pomeranian weighing 2.8 kg and an 11-year-old castrated male Shih tzu dog weighing 4.9 kg were presented to the Dana Animal Hospital Eye Center with corneal opacity in the right eye (OD). On initial ophthalmic examination, fluorescein dye test (Fluorescein sodium®, Optitech Eyecare, Allahabad, India) was negative in both eyes (OU) and the intraocular pressure (IOP) measured by the Tonovet® tonometer (Icare Finland Oy, Vantaa, Finland) were within normal range bilaterally in both cases. Ocular ultra-
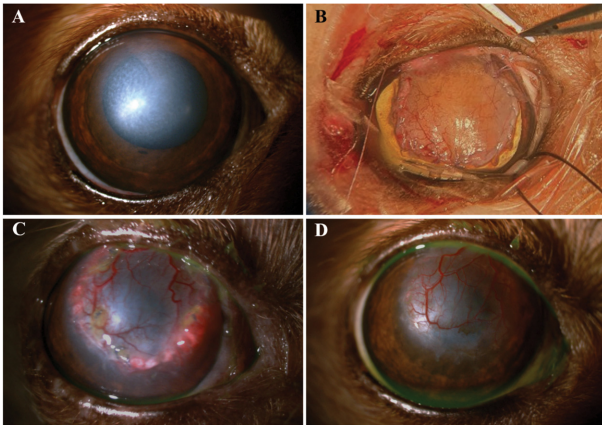
Fig 1. Pre- and postoperative appearances of the right eye in case 1. Preoperative photograph. Corneal edema and resulting corneal opacity were observed (A). Final aspect of SKCAHF. A simple continuous suture pattern using absorbable 9-0 Vicryl® suture was performed to anchor the conjunctival flap to the stromal defect margin (B). 20 days after surgery (C). 349 days after surgery. At this time, although mild pigmentation and scar formation were present at the conjunctival flap suture site, corneal edema and cloudiness were reduced, and they did not progress to other parts of the cornea (D).

Fig 2. Slit-lamp biomicroscopic photographs showing pre- and postoperative appearances of the right eye in case 2. Preoperative photograph. Corneal edema and resulting corneal opacity were observed on the dorsolateral side of the cornea (A). Preoperative slit image. Apparent increased dorsal corneal thickness and microcystic bullae were observed (yellow arrows) (B). 17 days after surgery (C). Decreased dorsal corneal thickness was observed in the optic section image (D). 231 days after surgery. Despite mildly scarred flap suture site, corneal edema and corneal opacity no longer progressed to other areas of the cornea (E). Corneal thickness was also maintained without thickening (F).

sound (LOGIQ P9®, GE Healthcare, Solingen, Germany) showed no remarkable findings OU in case 1 and linear hyperechoic material posterior to the iris, presumed to be artificial intraocular lens inserted during cataract surgery in the left eye (OS) before and no abnormalities OD in case 2. Menace response and dazzle reflex were all positive OU in both cases. Slit-lamp biomicroscopy (SL-D7®, Topcon Corp, Tokyo, Japan) showed superotemporal corneal edema and cloudiness in OD of both cases. Neither corneal pigmentation nor vascularization was present (Fig 1A, Fig 2A). Based on these results, glaucoma, anterior uveitis, lens luxation, and toxic damage or trauma to the corneal endothelium were excluded as causes of corneal edema, and the dogs were clinically diagnosed with corneal edema caused by endothelial degeneration. SKCAHF was planned to minimize corneal opacity so that vision can be maintained in both cases. After administering atropine (Atropine®, Daewon Pharm, Korea) 0.02 mg/kg SC, cefazolin (Cefazolin®, Chongkundang, Korea) 20 mg/kg SC, and one drop of topical 0.5% proparacaine (Alcaine®, Alcon, Korea), the dog was injected with butorphanol (Butorphan®, Myungmoon Pharm, Korea) 0.2 mg/kg IV and midazolam (Midazolam®, Bukwang Pharm, Korea) 0.2 mg/kg IV for pre-anesthesia and propofol (Provive®, Myungmoon Pharm, Korea) 6 mg/kg IV for anesthetic induction. General anesthesia was maintained with isoflurane (Isotroy 100®, Troika Pharm, India) and oxygen. After clipping periocular region, the surgical site, including the conjunctival sac, was disinfected with 0.5% povidone-iodine solution and lactated Ringer's solution (Hartman solution®, JW Pharm, Korea). The eyelid was retracted with a Barraquer eyelid speculum to maintain a sufficient surgical field. A corneal round (case 1) or linear (case 2) incision was made with a no.15 surgical blade in the edematous corneal region. Lamellar keratectomy was 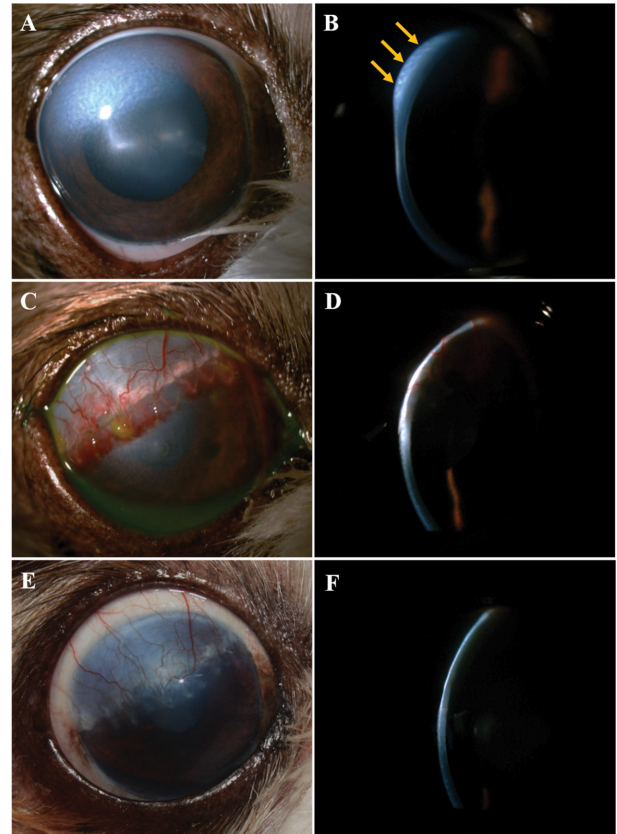performed with a 2.6 mm crescent microsurgical knife (Kai Medical, Tokyo, Japan) from the incision line to the adjacent limbus. The dissected corneal flap was excised with Vannas scissors. To cover the stromal defects, thin conjunctival hood flaps were made using Steven's curved tenotomy scissors. After the flaps were advanced to cover the keratectomized areas, the flaps were anchored to the incision margin with a cardinal suture to three sites and a simple continuous pattern using 9-0 polyglactin 910 (coated Vicryl®, Ethicon, Somerville, NJ, USA) (Fig 1B, Fig 2C). Partial temporary tarsorrhaphy was performed by a simple interrupted pattern using 6-0 nylon (Blue Nylon®, Ailee, Korea) to close half of the eyelid. Topical eyedrops, including 0.5% moxifloxacin q6h (Vigamox®, Alcon, Singapore), 1% tropicamide q6h (Mydriacyl®, Alcon, USA), and 5% NaCl ophthalmic solution q6h (Muro 128, Bausch&Lomb, USA) were instilled for 4 weeks. Systemic doxycycline (Unidoxy®, Kukje Pharm, Korea) 5 mg/kg BID was administered for 21 days, and an Elizabethan collar was applied to prevent self-injury for 28 days. When a partial temporary tarsorrhaphy suture was stitched out on the 20th and 17th day in case 1 and 2, respectively,

after surgery, conjunctival vessels invaded the cornea incision area and conjunctival hood flap integration was well maintained in both cases (Fig 1C, Fig 2C). At recheck 349th day (Fig. 1D) and 231st day (Fig. 2E) after surgery, mild scar formation was present at the conjunctival flap suture site, and corneal edema and corneal opacity were reduced and further progression to other parts of the cornea was not observed (Fig 1, Fig 2, Fig 4).

Case 3 (Corneal edema extended to the entire area of the cornea)

A 13-year-old castrated male Shih tzu dog weighing 5.3 kg was presented to the Dana Animal Hospital Eye Center with corneal opacity, blepharospasm, conjunctival hyperemia, and vision loss OS. A full ophthalmic examination was performed. Fluorescein dye test was negative OU. IOP were 19 mmHg OD and 17 mmHg OS. Ocular ultrasound revealed cataract and retinal detachment OD and no abnormalities except for cataract and numerous echogenic bodies in the vitreous OS. Menace response was negative OU, and dazzle reflex was negative OD and positive OS. Slitlamp biomicroscopy showed mature cataract OD and corneal edema showing cloudiness and neovascularization OS (Fig 3A). Based on these results, we ruled out glaucoma, anterior uveitis, and anterior lens luxation and the dog was diagnosed with corneal edema secondary to corneal endothelial degeneration, which caused vision loss OS. Since cataract was confirmed in OS by ocular ultrasound examination, surgical treatment using SKCAHF was planned to perform cataract surgery later when corneal edema would be reduced, and corneal transparency improved. The dog was premedicated with atropine 0.02 mg/kg SC, acepromazine (Sedaject®, Samu median, Korea) 0.2 mg/kg SC, cefazolin 20 mg/kg SC, tramadol (Tramadol®, Bukwang Pharm,
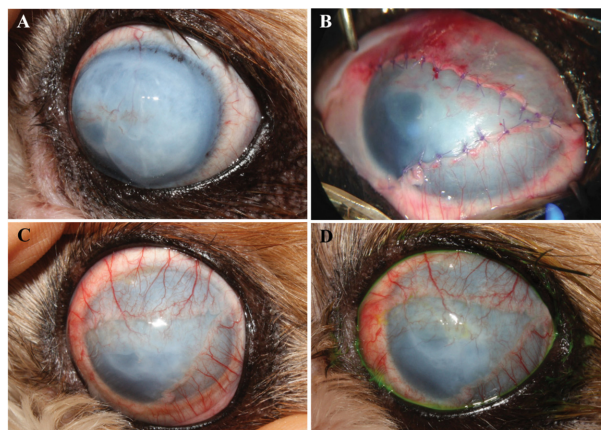

Fig 3. External photographs showing pre- and postoperative appearances of the left eye in case 3. Preoperative appearance. There were diffuse corneal opacity and edema throughout the cornea, and corneal neovascularization was also observed from the dorsomedial to the central cornea (A). Immediately after surgery. A simple interrupted suture pattern using absorbable 8-0 Vicryl® was applied to suture the two conjunctival flaps to the resected corneal margins (B). 59 days after surgery (C). 275 days after surgery. Superficial corneal neovascularization was apparent. Corneal opacity and corneal edema were less than before surgery, but they had not decrease completely 275 days after surgery (D).

Korea) 2 mg/kg SC, and meloxicam (Metacam, Boehringer Ingelheim, Spain) 0.2 mg/kg SC. Topical 0.5% proparacaine eyedrop was instilled. After anesthetic induction using ketamine (Ketamine®, Huons, Korea) 5 mg/kg IV, general anesthesia was maintained with isoflurane and oxygen. Surgical field preparation was performed in the same manner as in
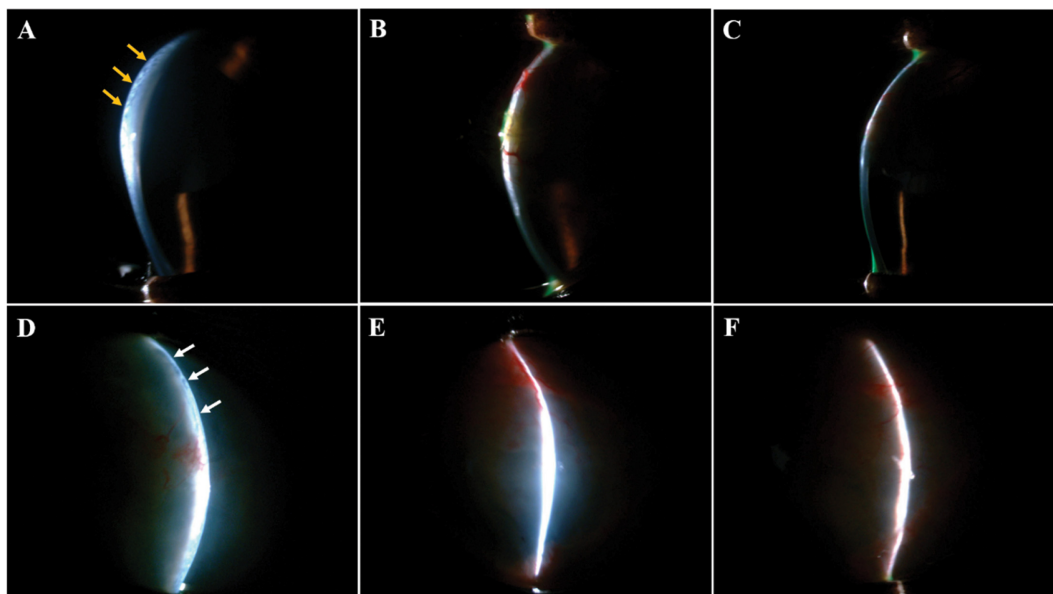

Fig 4. Corneal optic section images produced by slit beam in case 1 (A, B, C) and case 3 (D, E, F). In case 1, the dorsal thickened cornea and microcystic bullae in the anterior stroma (yellow arrow) were present in preoperative image (A). Corneal thickness gradually decreased at 20 days (B) and appeared normal at 349 days postoperatively (C). In case 3, bullae formation (white arrow) and generalized corneal edema were observed preoperatively (D). On 198 (E) and 275 days (F) after surgery, corneal bullae formation did not recur, but corneal edema remained.

cases 1 and 2. With the help of an ophthalmic surgical microscope, the first linear outlining incision was made with a no. 15 scalpel blade at a third of the corneal diameter. The second linear incision was inclined at an angle of 60 degrees to the first incision. This was to improve corneal opacity and edema in the dorsolateral area, where corneal cloudiness was most severe, and secure vision and the surgical field in case of phacoemulsification. Lamellar keratectomy and the preparation of two conjunctival flaps were performed in the same manner as in case 1. The flaps were sutured to the incision margin with a simple interrupted pattern using 8-0 polyglactin 910 (Fig. 3B). As in case 1, partial temporary tarsorrhaphy was performed using simple interrupted pattern with 6-0 nylon. Topical 0.5% moxifloxacin q6h and cyclopentolate q12h (Ocucyclo®, Samil Pharm, Korea) were applied for 21 days. The 5% NaCl ophthalmic solution was instilled q6h for 30 days. Systemic doxycycline 5 mg/kg BID was administered for 21 days, and an Elizabethan collar was placed to prevent self-trauma for 30 days. The partial temporary tarsorrhaphy sutures were removed 14 days after the surgery. On day 59th and 275th after surgery, the corneal opacity and corneal edema were less than before surgery, and the clinical signs, such as blepharospasm and corneal ulceration were not observed (Fig 3C, 3D). However, the corneal cloudiness had not fully regressed, and the negative menace response suggested that vision had still not recovered 275 days postoperatively (Fig 4).

Discussion

CED is characterized by fluid entering the corneal stroma due to decompensation of the corneal endothelial cells, resulting in diffuse corneal edema (11,16). Since the regeneration capacity of the corneal endothelium is little, corneal edema progresses gradually and causes stromal bullae formation, epithelial rupture, corneal ulcer, painful eye, and blindness (6,11,16).

Corneal endothelial cells can be directly evaluated for cell morphology or density using confocal microscopy or specular microscopy. When tested by confocal microscopy, the cell density of normal dogs has been reported to be 1805-3175 cells/mm^2, and reduced with increasing age (6,7,9). It has also been reported that endothelial dysfunction occurs when cell density is lowered to 500-800 cells/mm^2 (6). However, due to expensive equipment, confocal microscopy and specular microscopy are not commonly performed in veterinary ophthalmology, and CED is diagnosed by excluding secondary causes that can damage endothelial cells, such as glaucoma, uveitis, persistent pupillary membrane, endophthalmitis, lens luxation, keratitis, and toxic or surgical damage (3,6,8). In this case report, the dogs were also diagnosed by ruling out other causes of endothelial dysfunction through ophthalmic examination.

Although topical hyperosmotic agents, such as 5% sodium chloride solution used in the earliest stage, are known to reduce epithelial bullae formation and corneal ulceration, they do not reduce corneal stromal edema and therefore do not effectively improve the corneal transparency. In addition, there is a disadvantage that the effect of hyperosmotic agents decreases due to increase in tear secretion caused by ocular irritation after instillation, which causes drug dilution (6,10,11).

TKP, which is commonly performed in veterinary ophthalmology, is a method that prevents fluid from flowing into the corneal stroma by inducing the contraction of the stromal collagen fibers by performing superficial thermal cauterization at multiple points (6,12). After TKP treatment, corneal cloudiness decreased slightly and the ocular discomfort resolved, but superficial corneal neovascularization, stromal fibrosis, and scarring occurred (5,6,11,12). Michau et al. performed TKP in 13 dogs with bullous keratopathy due to endothelial diseases. After follow-up period of 67.4 ± 68 weeks, the owners reported that visual ability did not improve or worsen compared to before TKP (12). Therefore, TKP is not aimed at improving vision, but rather to cause fibrosis of the corneal stroma to prevent recurrent bullae formation, corneal ulcers, and ocular pain (6,12).

In this case report, we decided to perform SKCAHF, which has been reported to reduce corneal edema and improve vision by reducing corneal thickness by debulking and vascular drainage of fluid in dogs because the purpose of treatment was to improve vision by reducing corneal edema and cloudiness (8,11).

In case 3 where the entire cornea was edematous and cloudy, two hood flaps were applied to cornea. On the other hand, in cases 1 and 2, corneal edema and opacity were observed in a part of the cornea, and only one hood flap was performed. Brooks et al. reported that with the progression of corneal endothelial disease, the Descemet's membrane thickened and normal hexagonal endothelial cells underwent histologic changes and formed a fibrocellular posterior collagenous layer (4). In case 3, where the entire cornea was diseased, corneal edema and cloudiness were slightly reduced following the surgery, but the vision was still poor because corneal transparency had not clearly improved 275 days after surgery (Fig 3, Fig 4). However, in cases 1 and 2, mild scar formation was present at the conjunctival flap suture site. Additionally, corneal edema and cloudiness were reduced and vision was well-maintained for 349 days and 231 days postoperatively (Fig 1, Fig 2, Fig 4).

Therefore, it may be considered that it is better to perform SKCAHF as early as possible during the development of the disease. However, studies on the difference between the times of application and prognosis after surgery at different stages of the disease, whether corneal edema or cloudiness, are still insufficient.

The limitations of this case report include the following: the follow-up duration was relatively short, and the number of cases was not large enough for predicting long-term prognosis of this surgery. In addition, when one or two hood flaps are made and applied with SKCAHF method, a comparative study is needed to determine whether there is a difference in vision improvement and maintenance duration depending on the number of flaps. Third, it is necessary to investigate the effect on improving vision and corneal transparency and maintenance time between various treatment methods, such as TKP, SKCAHF, superficial keratectomy, penetrating keratoplasty, endothelial keratoplasty, and corneal collagen crosslinking technique.

Conclusions

When corneal edema was observed only in a part of the cornea, it was effectively reduced and did not progress to other parts of the cornea after SCKAHF. However, in the case of CED in which the entire cornea was clouded, corneal opacity was partially reduced, but it was still maintained. These results suggest that SKCAHF may have a better prognosis when corneal edema caused by CED is as low as possible. Further research is needed to investigate the effects of SKCAHF at different stages of corneal edema due to CED in many dogs.

Conflict of Interest

All authors declare no conflicts of interest.

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