Evaluation of Sutureless Cataract Surgery in the Dog

Joon Young Kim, DVM, MSc, PhD[1]
Soon-wuk Jeong, DVM, MSc, PhD[2]
Hyun-jung Han, DVM, MSc, PhD[3]
David L Williams, MA, VetMB, PhD, CertVOphthal, FRCVS[1]

[1]Department of Veterinary Medicine
Cambridge, United Kingdom

[2]Department of Veterinary Surgery
College of Veterinary Medicine
KonKuk University
Seoul, Republic of Korea

[3]Biomedical Physics Laboratory
School of Physics and Astronomy
Seoul National University
Seoul, Republic of Korea

KEY WORDS: sutureless cataract surgery, refractive error, intraocular pressure, neovascular formation at the cornea, dog

ABSTRACT

This study evaluated the effectiveness of sutureless cataract surgery using a clear corneal incision in canine cataract surgery. Sutured cataract surgery was compared with sutureless cataract surgery in terms of the refractive error, the alteration of intraocular pressure (IOP) over 28 days post-operatively, and neovascularization on the cornea. An average of 1.33 ± 0.58 D astigmatism was induced in sutured cataract surgery, but this was not present in sutureless cataract surgery. Suture placement did not significantly affect the IOP over 28 days after surgery. Neovascularization of the cornea was not noticeably different between the wounds of the sutured and sutureless eyes. From this study, sutureless cataract surgery through a clear corneal incision is an effective surgical method as it does not produce any astigmatism, has no postoperative effects on IOP, and does not cause significant corneal neovascularization.

INTRODUCTION

It has been widely acknowledged that successful cataract surgery should restore the functional vision of the patient.[1] Veterinary ophthalmologists, however, are now considering how to optimize the vision of a dog whose cataractous lens has been removed. In addition to increasing the surgical success rate and lessening the postoperative complications, determining how emmetropia can best be restored post-operatively will improve the patient's quality of life after surgery. The extent to which dogs require emmetropia is still the subject of debate because dogs have limited accommodative power and lack a cone-rich high-resolution macula. However, refractive correction has previously been shown to be beneficial in work demonstrating that optical defocus decreases visual acuity in dogs.[2] Astigmatism, a complication that may result from any corneal incision, was first reported in canine cataract surgery by Pollet in 1982.[3] In 21% of the aphakic eyes examined in his study, astigmatism remained 3 weeks after the operation.

When phacoemulsification was developed in people, it was predicted that 3-mm incisions would be astigmatism-neutral because of their small size.[4] This forecast has become a reality with the development of small-incision injectable lenses. Small-incision cataract surgery has made sutureless cataract surgery possible in humans, and has reduced postoperative astigmatism, which was a considerable problem after extracapsular cataract extraction.[5] In veterinary medicine, the development of a foldable intraocular lens (IOL) has made small-incision cataract surgery possible.[6,7] To the authors' knowledge, however, sutureless canine cataract surgery has not been described in the peer-reviewed literature until the work reported herein.[8,9] An advantage of the clear corneal incision is that the incision size may be reduced, which facilitates self-sealing and decreases postoperative astigmatism.

Although phacoemulsification requires a 2.7- to 3.5-mm incision, the wound must be enlarged to at least 6-8 mm to permit the implantation of a rigid polymethylmethacrylate (PMMA) IOL.[7] The use of foldable IOLs, however, does not require the enlargement of the incision after phacoemulsification. As such, the use of this technique should decrease the cases of postoperative astigmatism and would lessen wound-related complications, such as dehiscence. Moreover, suturing of the corneal incision should not be needed with the foldable IOL because of the small incision size. Only 3 studies have thus far been conducted regarding the implantation of a canine foldable IOL. Gaiddon et al[6] in 1997 implanted a 41-D lens, made of silicone of dimethylsiloxane-diphenylsiloxane copolymer with PMMA haptics. This lens was implanted through a 4.5-mm corneal incision. The results of the second study were published by the same group in 2000.[7] In that study, a 41-D lens with a tripodal design and a maximum diameter of 12 mm was used. The 3.5-mm corneoscleral incision was extended to 4.1 mm after phacoemulsification for the insertion of the IOL. The incision was closed with a single X-shaped suture. The use of an IOL injector through the clear corneal incision makes it possible to close the incision through self-sealing. In the third study of 2006, Yi et al[10] evaluated injectable acryl foldable IOLs. In this study, a 3-mm clear corneal incision was used, closed with 8-0 polyglactin 910 sutures.[10] Astigmatism was not assessed in any of these studies.

The objective of the present study was to evaluate the effectiveness of sutureless cataract surgery using a clear corneal incision in canine cataract surgery. For this, sutured and sutureless cataract surgery was compared in terms of (1) refractive error, both in horizontal and vertical meridian; (2) change in intraocular pressure (IOP), and (3) neovascularization at the incision site.

MATERIALS AND METHODS

Animals

The subjects of this study were 6 healthy Beagle dogs, 3 females and 3 males, all of which were normal based on the results of the physical, hematological, serological, radiographic, and ocular examinations. The average age was 12.2 ± 3.5 months with range from 8 to 16 months, and mean weight was 9.4 ± 1.8 kg, with a range from 8.0 to 11.7 Kg.

The Beagles' 12 eyes were divided into 2 groups, namely: suture group (3 eyes) and non-suture group (9 eyes). In non-suture group, IOLs were inserted in 3 eyes and not in the other 6 eyes.

All dogs underwent physical examination, thoracic radiography, complete blood count (CBC), and serum chemistry to determine if they had any systemic disease. Schirmer tear test (STT) (Color Bar™, EagleVision, Inc., Memphis, TN, USA), applantation tonometry (TONO-PEN VET™, Reichert, Inc., Depew, NY, USA), monocular indirect ophthalmoscopy (Welch Allyn®, Skaneateles Falls, NY, USA), and slit lamp biomicroscopy (303-V, Takagi Mfg, Co., Japan) were conducted on all the dogs.

Perioperative Medication, Ophthalmic Anesthesia, and Surgical Exposure

For the control of postoperative iridocyclitis, the perioperative drug administration schedules were strictly followed, as shown in Table 1. Surgery was undertaken under routine anesthesia with atropine sulfate (atropine sulfate injection. Je Il Pharm. Co.

Table 1. Perioperative drug administration schedules for cataract surgery.

Preoperative	Drugs
4 days	Systemic carprofen (Rimadyl®, Pfizer, USA, 2.2 mg/kg, BID, PO)
24 hours	Topical 1% atropine (OcuTropine Eye Drops, Samil Pharm. Co. Ltd., Korea, Q6H)
	Topical 1% prednisolone acetate (OcuPred Eye Drops, Samil Pharm. Co. Ltd., Korea, Q6H)
	Topical ofloxacin (Telbit Eye Drops, Daewoo Pharm. Co. Ltd., Korea, Q6H)
	Systemic amoxicilline (Penbrex® injection, Yungjin Pharm. Co. Ltd., Korea, 20 mg/kg, BID, IV)
2 hours	Topical 1% atropine (OcuTropine Eye Drops, Samil Pharm. Co. Ltd., Korea, Q30M)
	Topical antibiotics and dexametasone (Forus Eye Drops, Samil Pharm. Co. Ltd., Korea, Q30M)
	Topical flurbiprofen sodium (Ocufen™ Liquifilm® Eye Drops, Allergan, Westport Co. Ireland, Q30M)
	Topical 2.5% penyllephrine hydrochloride (2.5% Mydfrin® sterile ophthalmic solution, Alcon Laboratories, Inc., USA, Q30M)
10 minutes	Systemic dexamethasone (Dexamethasone Disodium Phosphate Injection, Sinil Pharm. Co. Ltd., Korea, 0.5 mg/kg, IV)

Ltd., Korea, 0.03 mg/kg, SC) and butorphanol tartrate (Butophan® injection 1 mg, Myungmoon Pharm. Co. Ltd., Korea, 0.4 mg/kg, IV) premedication, thiopental sodium (Thionyl injection, Dai Han Pharm. Co. Ltd., Korea, 12 mg/kg, IV) induction, intubation, and maintenance with isoflurane (Isoflurane, Rhodia Organique Fine Ltd., UK) in 100% oxygen with muscle relaxation with atraculium besylate (Acrium® injection, Myungmoon Pharm. Co. Ltd., Korea, 0.2 mg/kg, IV) followed by mechanical ventilation support. The eye was routinely prepared for surgery using 0.5% povidone-iodine solution to sterilize for ocular surface.

Surgical Technique

Clear Corneal Incision

The clear corneal incision described by Fine[5] was adopted with slightly modification.[11] An initial groove was made at the 10-12 o'clock position 1 mm beyond the limbus (Figure 1). A 3.0-mm corneal knife (REF 52-3035, Stylus®, Surgical Specialties Co., Reading, PA, USA) was then inserted in the plane of the cornea up to a depth of 1.75 mm. The dimple-down technique was then used to initiate the cut through Descemet's membrane (Figure 1)[5] for multiple-planes-of-incision construction. After entering the anterior chamber, the initial plane of the knife was reestablished to cut though Descemet's membrane in a straight-line configuration. In this manner, a stepwise corneal incision is made providing a multiple-plane valve-like tunnel closure.

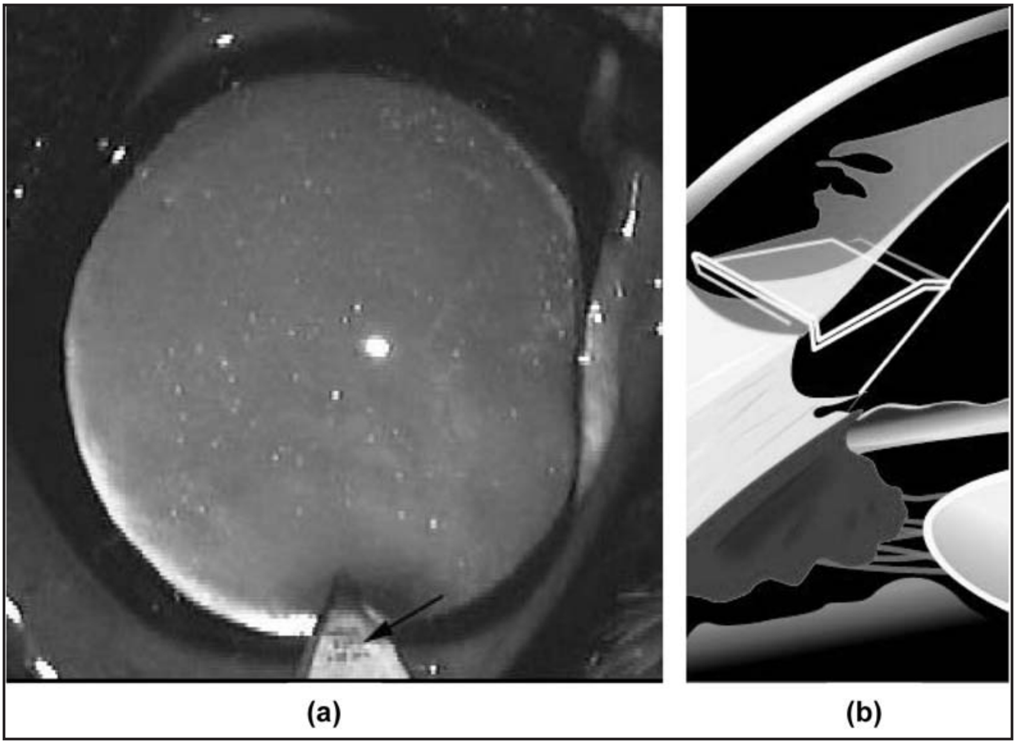
Continuous Curvilinear Capsulorhexis (CCC) and Hydrodissection

The aqueous humor in the anterior chamber was replaced by a viscoelastic material (Amvisc® Plus, Bausch & Lomb, Inc., Rochester, NY, USA) through the corneal tunnel. The capsulorhexis was performed with the use of a bent 23-gauge needle and capsulorhexis forceps. After the CCC, hydrodissection was conducted with the use of a balanced salt solution (BSS) (Balon-A solution, Dai Han Pharm. Co. Ltd., Korea).

Phacoemulsification

At the 2 o'clock position and 1 mm beyond the limbus, a sideport incision was made with the use of a 15° stab knife with a restricted-depth, straight, 3.0-mm blade (REF 52-1531, Stylus®, Surgical Specialties Co., Reading, PA, USA). Phacoemulsification was then performed using a Phacojack (Howard Instruments, Inc., Tuscaloosa, AL, USA). For the division of the nucleus, the crater divide-and-conquer technique was

Figure 1. The clear corneal incision for sutureless cataract surgery (a) photograph and (b) cross-sectional view of the shallow groove. First, for the clear corneal incision, an initial groove was made at the 10-12 o'clock position and about 1 mm beyond the limbus. A 3.0-mm clear corneal knife was then inserted in the plane of the cornea up to a depth of 1.75 mm (arrow). The dimple-down technique was then used to initiate the cut through Descemet's membrane.



used.[12] After the creation of a central crater, the nuclear rim was fractured using the bimanual method. The lens was rotated, and a second lens division was made, isolating several pie-shaped sections. The nuclear rim was then rotated clockwise, facilitating systemic piece-by-piece removal. Next, the residual cortex was completely removed with the use of automated I/A (irrigation/ aspiration) with BSS, to polish the posterior lens capsule and remove any remaining lens material from the equatorial and posterior regions.

Among the non-suture group eyes, a foldable IOL (Tek-Lens, Model: 614VE, TEKIA, Inc., Irvine, CA, USA) was implanted in 3 eyes. For this, the incision was enlarged to 3.2 mm.

Closing Incision

For the suture group, three tightly interrupted sutures were placed with 8-0 polygalctin 910 (W9560, Vicryl®, Ethicon®, UK). The sideport incision was not sutured.

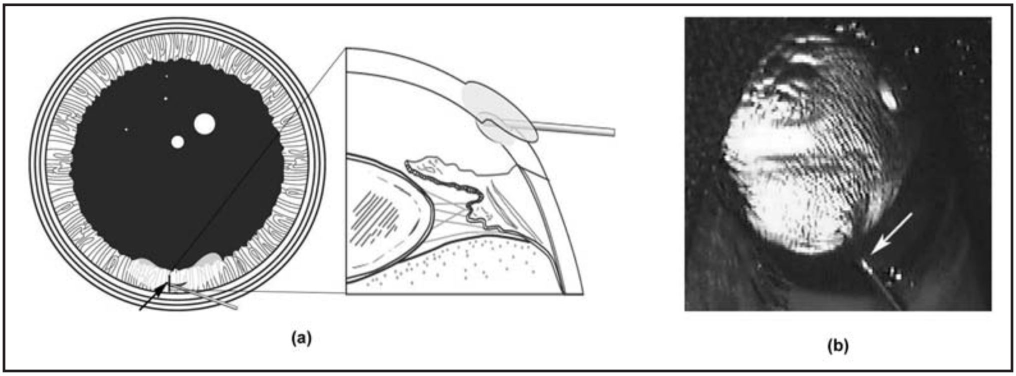
For the non-suture group, stromal hydration of the clear corneal incision was conducted to facilitate self-sealing by placing the tip of a 27-gauge cannula on the side walls of the incision, and gently irrigating the BSS into the stroma (Figure 2). The incision line was then checked with the use of Lasik Eye Spear (7306, Hurricane Medical, Bradenton, FL, USA) to ensure that it was watertight. To control and resolve iridocyclitis, postoperative treatment was performed, as shown in Table 2.

Evaluation of Refractive Error, Intraocular Pressure, and Neovascularization on the Cornea

Refractive Error

Before surgery, the refractive error of the eye was evaluated with the use of a streak retinoscope (Welch Allyn®, Skaneateles

Figure 2. Stromal hydration of the clear corneal incision (a) schematic drawing and (b) photograph. After placing the tip of a 27-gauge cannula on the side walls of the incision (black (a) and white (b) arrow), irrigation the BSS into the stroma.



Falls, NY, USA) with a retinoscopy bar. The working distance was 67 cm (1.5 D). Both the refracting horizontal and vertical meridia were measured. For the cycloplegic refraction (CR), 1% atropine was administered. Each eye was evaluated 3 times in each examination. The average of the 3 results was used to the given mean refraction for each eye. At 28 days postoperatively, all the eyes in the 2 groups were also refracted using the same method.

The surgically induced astigmatism was determined as follows:

First, the change of horizontal refraction (ΔK1) was determined by subtracting the preoperative refraction of the horizontal axis (prK1) from the postoperative refraction on the horizontal axis (180°) (poK1). Then, the change of vertical axis (ΔK2) was determined by subtracting the preoperative refraction of the vertical axis (prK2) from the postoperative refraction on the vertical axis (90°) (poK2). The difference between the change of horizontal refraction and that of vertical refraction (cK) was determined by subtracting ΔK2 from ΔK1.

$$\Delta K1 = poK1 - prK1$$

$$\Delta K2 = poK2 - prK2$$

$$cK = \Delta K1 - \Delta K2$$

Postoperative Evaluation

The preoperative IOP was measured using the TONO-PEN VET™ 1 hour before surgery. The postoperative IOP was measured 5 hours postoperatively, and then was measured every day for 28 days, under local anesthesia (Proparacaine Hydrochloride Ophthalmic Solution USP, 0.5%, Bausch & Lomb, Inc., Rochester, NY, USA).

Each day after the operation for 28 days, the corneas of all dogs were evaluated at the incision site with the use of a slit lamp. At the final evaluation, photographic documentation was used and for this, dogs were sedated by administering medetomidine (Dormitor®, Orion Pharma, Finland, 45 μg/kg, IV).

Each day postoperatively, the menace response was recorded for each eye in each dog. At 28 days postoperatively, all dogs were evaluated with an obstacle test.

Statistical Analysis

Statistical analysis was undertaken using the Mann-Whitney U test to evaluate the differences between the cK results of the 2 groups. The alteration of the IOP after the operation in the 2 groups was analyzed statistically through the Mann-Whitney U test.

In each test, $P < 0.05$ was considered significant. All the probabilities for the differences were generated using SPSS (SPSS 12.0 KO for Windows).

RESULTS

The phacoemulsification time was 0.48 ± 0.32 min (mean ± SD) with a range of 0.1-0.9 min. Average surgery time was 30 minutes.

Table 2. Postoperative treatment schedules for cataract surgery.

Postoperative	Drugs	
	Topical	Systemic
0-2 days	1% atropine (Q6H)	Amoxicillin (Pamoxin® Capsules, Dong Hwa Pharm. Inc. Co. Ltd., Korea, 20 mg/kg, BID, PO)
	Antibiotics and dexametasone (Q6H)	Prednisolone (Prednisolone Pharma Tab., Korea Pharm Co. Ltd., Korea, 1 mg/kg, BID, PO)
	Flurbiprofen sodium (Q6H)	Cimetidine (Cimetidine Union Tab., Union Korea Pharm Co. Ltd., Korea, 10 mg/kg, BID, PO)
	2.5% penyllephrine hydrochloride (Q6H)	
3-7 days	1% atropine (Q8H)	Amoxicillin (20 mg/kg, BID, PO)
	Flurbiprofen sodium (Q8H)	Prednisolone (1 mg/kg, BID, PO)
	2.5% penyllephrine hydrochloride (Q8H)	Cimetidine (10 mg/kg, BID, PO)
	1% prednisolone acetate (Q8H)	
	Ofloxacin (Q8H)	
8-14 days	1% atropine (Q24H)	Amoxicillin (20 mg/kg, BID, PO)
	1% prednisolone acetate (Q8H)	Prednisolone (0.5 mg/kg, BID, PO)
	Ofloxacin (Q8H)	Cimetidine (10 mg/kg, BID, PO)
15-21 days	1% prednisolone acetate (Q8H)	Amoxicillin (20 mg/kg, BID, PO)
	Ofloxacin (Q8H)	Prednisolone (0.25 mg/kg, BID, PO)
	2.5% penyllephrine hydrochloride (Q8H)	Cimetidine (10 mg/kg, BID, PO)
22-28 days	1% prednisolone acetate (Q12H)	Carprofen (Rimadyl®, Pfizer, USA, 2.2 mg/kg, BID, PO)
	Ofloxacin (Q12H)	

Refractive Error

Before the operation, all eyes were emmetropic, and there was no astigmatism (Table 3). After surgery, refractive errors were induced in some dogs.

The eyes in which IOL was not inserted became hypermetropic at 18.39 ± 1.33 D (mean ± SD), while the other eyes in which an IOL was inserted became slightly myopic (-0.94 ± 0.73 D) after surgery. These 2 refractions were significantly different ($P < 0.05$).

Comparing the surgically induced change of refractive error between sutured and non-sutured procedures, the sutured group (1.39 ± 0.48 D) had significantly greater astigmatism than the non-sutured group (0.02 ± 0.07 D; $P < 0.05$; Table 4), the surgically induced astigmatism in suture cataract surgery (1.33 ± 0.58 D) being significantly greater from that in sutureless cataract surgery (0.00 ± 0.00 D; $P < 0.05$; Table 3).

Intraocular Pressure (IOP)

The preoperative IOP was 16.2 ± 1.11 mmHg with range from 15 to 18 mmHg. The changes in IOP after cataract surgery are shown in Figure 3. Most of the mean IOPs of each group were within the normal range (12-20 mmHg), IOP was not significantly changed after surgery in both groups, and the alteration in IOP was not significantly different between 2 groups ($P > 0.05$).

Neovascularization at the Incision Site

All the dogs appeared to be seeing clearly 28 days postoperatively, all the eyes responded normally to the menace test, and dogs nego-

Table 3. The refractive error of Beagles' eyes before and after cataract surgery (mean ± SD; minimum to maximum).

Group	Before Surgery			After Surgery		
	Spherical	Cylindrical*	SEq	Spherical	Cylindrical*	SEq
Suture (aphakic)	-0.08 ± 0.22 D (-0.33 to 0.08 D)	-0.06 ± 0.17 D (-0.25 to 0.08 D)	-0.11 ± 0.19 D (-0.33 to 0.04 D)	18.28 ± 0.77 D (17.83 to 19.17 D)	1.33 ± 0.58 D (1.00 to 2.00 D)	18.94 ± 0.68 D (18.33 to 19.67 D)
Non-suture (aphakic)	-0.15 ± 0.41 D (-0.83 to 0.42 D)	-0.03 ± 0.04 D (-0.08 to 0.00 D)	-0.17 ± 0.41 D (-0.88 to 0.38 D)	18.11 ± 1.54 D (16.50 to 20.50 D)	0.00 ± 0.00 D (0.00 to 0.00 D)	18.11 ± 1.54 D (16.50 to 20.50 D)
Non-suture (pseudophakic)	-0.39 ± 0.48 D (-0.92 to 0.00 D)	-0.06 ± 0.10 D (-0.17 to 0.00 D)	-0.42 ± 0.52 D (-1.00 to 0.00 D)	-0.94 ± 0.73 D (-1.75 to -0.33 D)	0.00 ± 0.00 D (0.00 to 0.00 D)	-0.94 ± 0.73 D (-1.75 to -0.33 D)
All non-suture	-0.23 ± 0.42 D (-0.92 to 0.42 D)	-0.04 ± 0.06 D (-0.17 to 0.00 D)	-0.25 ± 0.44 D (-1.00 to 0.38 D)	11.76 ± 9.61 D (-1.75 to 20.50 D)	0.00 ± 0.00 D (0.00 to 0.00 D)	11.76 ± 9.61 D (-1.75 to 20.50 D)
All eyes	-0.19 ± 0.37 D (-0.92 to 0.42 D)	-0.04 ± 0.09 D (-0.25 to 0.08 D)	-0.22 ± 0.39D (-1.00 to 0.38 D)	13.39 ± 8.72 D (-1.75 to 20.50 D)	0.33 ± 0.65 D (0.00 to 2.00 D)	13.56 ± 8.82 D (-1.75 to 20.50 D)

D = diopter; SEq = spherical equivalent; After Surgery = 28 days postoperatively.
*All axes were 180°, except 1 case (90°) before surgery.

Figure 3. The changes in IOP after cataract surgery. 0.21 days = 5 hours postoperatively; the alteration in IOP was not significantly different between 2 groups ($P > 0.05$). (The alteration of the IOP after the operation in the 2 groups was analyzed statistically through the Mann-Whitney U test.)

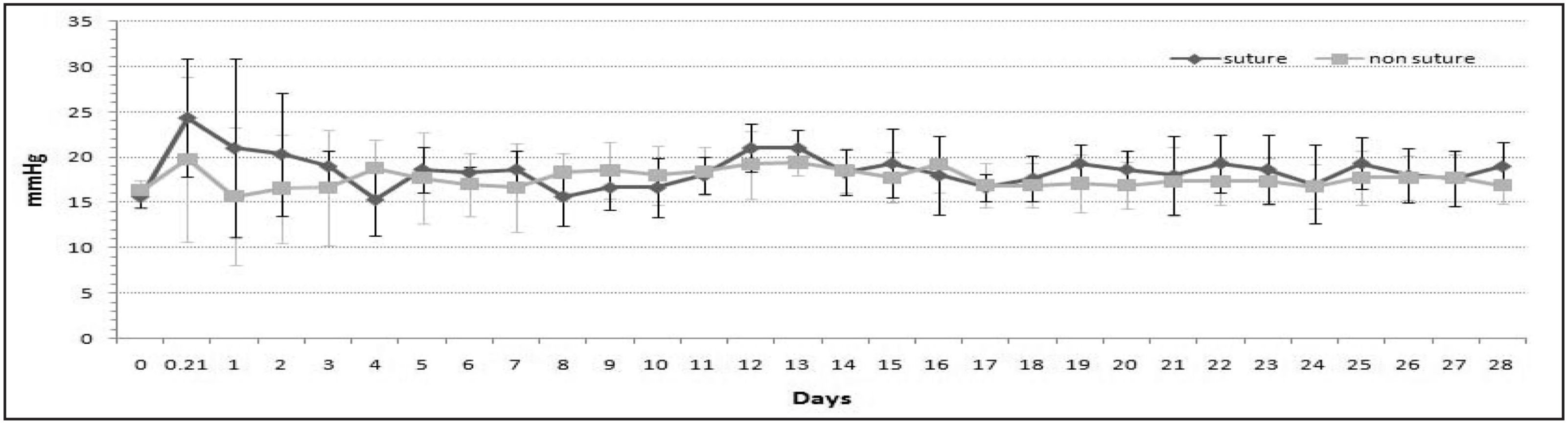


Table 4. The surgically induced change of refractive error (mean ± SD).

Group	ΔK1	ΔK2	cK*
Suture	19.75 ± 0.59 D	18.36 ± 0.65 D	1.39 ± 0.48 D
Non-suture	12.02 ± 9.48 D	12.00 ± 9.51 D	0.02 ±0.07 D

ΔK1 was determined by subtracting the preoperative refraction of the horizontal axis (prK1) from the postoperative refraction on the horizontal axis (180°) (poK1) (ΔK1 = poK1 – prK1).

ΔK2 was determined by subtracting the preoperative refraction of the vertical axis (prK2) from the postoperative refraction on the vertical axis (90°) (poK2) (ΔK2 = poK2 – prK2).

cK was determined by subtracting ΔK2 from ΔK1 (cK = ΔK1 – ΔK2).

*cK was significantly different between the 2 groups ($P < 0.05$) (calculated through the Mann-Whitney U test).

tiated the obstacle course without incident. The optic zone on the cornea was clear, but a small scar remained at the incision site (Figure 4), where small blood vessels from the limbus and the bulbar conjunctiva invaded in all eyes (Figure 4), but not reaching as far as the corneal incision site; all the scars were less than 3 mm wide. No differences were found in the degrees of neovascularization and scar formation between the 2 groups.

DISCUSSION

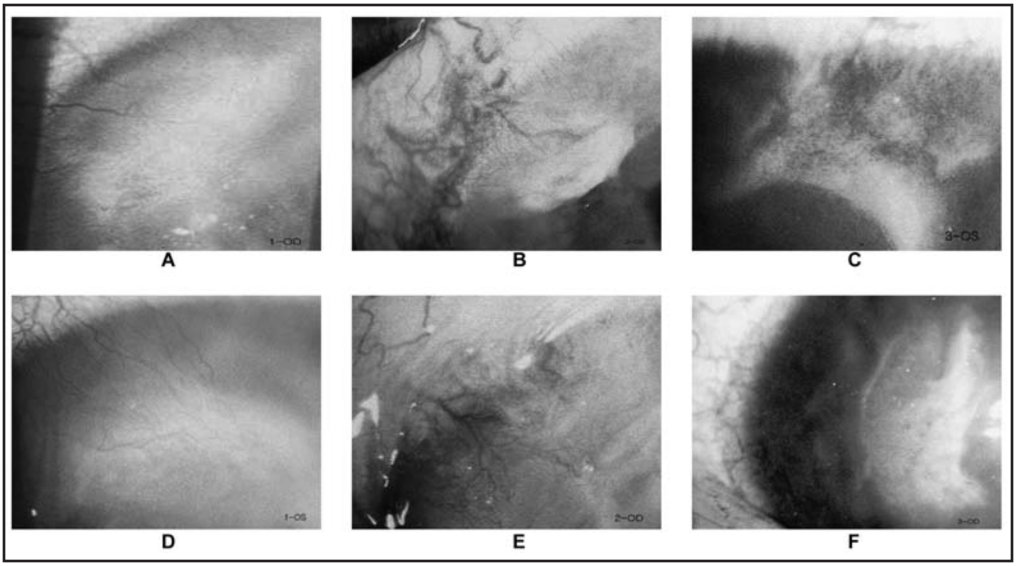
With the dramatic development of phacoemulsification in the past decade, cataract surgery can now be performed with a small incision. This technique allows surgeons to increase wound stability, reduce ocular trauma, and hopefully eliminate postoperative astigmatism and promote more rapid recovery of optimal vision.[13-15]

For small-incision human cataract surgery, posterior-limbal and clear corneal incisions can now be used with local rather than general anesthesia. Although clear corneal incisions have the disadvantage of the higher occurrence of astigmatism with limbal incisions, most surgeons prefer this technique because it allows a good surgical field of vision, has a low occurrence of hemorrhage, and is surgically convenient.

In veterinary medicine, clear corneal-, limbal-, and scleral-based incisions were described by Nelms et al[16] in 1994. In spite of the advantages of the scleral approach over the corneal approach, such as decreased corneal astigmatism, decreased corneal scarring and edema, and greater wound stability, the use of the corneal approach has prevailed because of ease of wound closure and the disadvantages of the scleral approach, such as excessive bleeding at the incision site, difficulty in aspirating the cortical material from the ventral capsular bag, and iris prolapse into the surgical wound. In canine cataract surgery to date, all corneal incisions have been closed with 1 or more sutures.[1,7,17-19] Pollet[3] reported the occurrence of 1 ~ 2 D astigmatism in 36% of eyes after performing clear corneal-incision cataract surgery. In the study conducted by Nelms et al,[16] however, the degree of surgically induced astigmatism in the corneal-approach group was 4.44 ± 3.4 D immediately postoperatively, and 2.35 ± 1.3 D one month postoperatively. In the present study, in the sutureless eyes (whether aphakic or pseudophakic), no astigmatism occurred after the cataract surgery (Tables 3 and 4). The sutured eyes, however, had 1.33 ± 0.58 D astigmatism after the cataract surgery, and the difference in the degree of astigmatism between the sutured and non-sutured groups was significant (Table 4). In the present study, the sutures were accomplished by using three tight, simple, interrupted sutures similar to those used in the study conducted by Chahory et al.[19] In the present study, all the surgically induced astigmatisms were exceptions to the rule because incision and suture were carried out at the 10-12 o'clock position. Since the cornea would be pulled through the 90° axis, the 180° axis might become flatter. In the sutured group, all the ΔK1s (horizontal axis) were greater than the ΔK2s (vertical axis). Thus, the surgically induced astigmatism showed a tendency to go against the rule. The wound is made at 10-12 o'clock instead of 3 o'clock as a 'gape' when blinking may occur.

Refractive studies of normal canine eyes have reported that most of the eyes were em-

Figure 4. The biomicroscopic photograph of the incision site 28 days postoperatively. A, B, and C are the sutured group. D, E, and F are the non-sutured group.



metropic within 1 D.[3,20] The eyes of all the experimental dogs in the present study were likewise emmetropic pre-operaively, with no astigmatism in any of the eyes (Table 3). In the aphakic eyes, postoperatively all eyes were hypermetropic, at 18.39 ± 1.33 D. This refractive error is higher than 14 D as reported by Pollet[3] in 1982 and 14.4 D as reported by Davidson et al.[21]

Tight wound closing with suture, might generate an initial increase in the IOP.[22] Five hours postoperatively, the mean IOP of the suture group (24.33 ± 6.51 mmHg) has indeed higher than that of the sutureless group (19.78 ± 9.08 mmHg), although the difference was not statistically significant ($P > 0.05$). This trend continued for 3 days, but no statistically significant difference was seen (Figure 3). If the wound was closed with a suture, the tension arising from the suture may make the trabecular meshwork narrow, resulting in an acute though small increase in the postoperative IOP.

The comparison of the incision sites with and without suture may provide information of surgical wound healing. In the present study, neovascularization invaded from the cornea to the incision site, and disappeared slowly. Throughout the 28 days postoperatively, small blood vessels were observed with the use of a biomicroscope, and no difference between the sutured group and the sutureless group was detected. One might have expected the suture to provoke a visibly different response from the non-sutured cornea but this did not occur.

Incisional weakness may induce wound dehiscence, which reduces the structural integrity of the optical quality of the eye. Wound construction is the critical determinant of wound integrity, and the 2 key elements of a wound are its size and architecture.[13,14] The clear corneal wound construction, which retains an adequate tunnel length with an internal corneal valve, is the key to a self-sealing wound.

CONCLUSION

To evaluate sutureless cataract surgery through clear corneal incision in a normal Beagle dog's eyes, the refractive state, IOP, and neovascularization at the incision site of eyes after phacoemulsification surgery with and without suture were compared. In the refractive state, although astigmatism was not induced in sutureless cataract surgery, 1.33 ± 0.58 D (mean ± SD) astigmatism was induced in cataract surgery with corneal suture ($P < 0.05$). With regard to postoperative IOP alteration, although the mean IOP of the suture group was higher than that of the sutureless group for 3 days, the difference was not statistically significant. At 28 days postoperatively, the difference in the IOP between the groups was not statistically significant ($P > 0.05$). Neovascularization at the cornea was not significantly different between the suture and sutureless groups, and wound healing progressed appropriately in both groups. Based on the above results, it can be concluded that sutureless cataract surgery with the implantation of a foldable IOL through clear corneal incision is an effective surgical method.

ACKNOWLEDGEMENTS

The authors thank Mr. Jeong Hoon Choi, optometrist at the Department of Ophthalmology, Uijongbu St. Mary Hospital, College of Medicine, The Catholic University of Korea for his help in refracting the eyes. J.Y. Kim and S.W. Jeong contributed equally to this work as the co-first authors.

REFERENCES

1. Nasisse MP, Davidson MG: Surgery of the lens. In: Gelatt KN, ed. *Textbook of Veterinary Ophthalmology*. 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 1999:827-856.
2. Murphy CJ, Mutti DO, Zadnik K, Hoeve JV: Effect of optical defocus on visual acuity in dogs. *Am J Vet Res* 1997;58(4):414-418.
3. Pollet L: Refraction of normal and aphakic canine eyes. *J Am Vet Med Assoc* 1982;18:323-326.
4. Kelman CD: Phaco-emulsification and aspiration. A new technique of cataract removal. A preliminary report. *Am J Ophthalmol* 1967;64(1):23-35.
5. Fine IH, Hoffman RS, Packer M: Incision construction. In: Steinert RF, ed. *Cataract Surgery: Technique, Complication, and Management*. 2nd ed. Philadelphia, PA: Saunders, An imprint of Elsevier Science; 2004:121-135.
6. Gaiddon J, Rosolen SG, Lallement PE, Le Gargasson JF: New intraocular lens (IOL) for dogs: the foldable CANI 15S. Preliminary results of surgical technique. *Invest Ophthalmol Vis Sci* 1997;38:S179.
7. Gaiddon JA, Lallement PE, Peiffer RL Jr: Implantation of a foldable intraocular lens in dogs. *J Am Vet Med Assoc* 2000;216(6):875-877.
8. Kim JY, Yoon HY, Han HJ, et al: Phacoemulsification for the treatment of hypermature or mature cataracts in dogs (abstract). The 13th Federation of Asian Veterinary Association Congress, October 2004: Abstract 144.
9. Kim JY, Youn HY, Han HJ, et al: Implantation of a foldable intraocular lens in dogs with cataract: 3 eyes (abstract). *J Vet Clin* 2005;22(Suppl):108.
10. Yi NY, Park SA, Jeong MB, et al: Phacoemulsification and acryl foldable intraocular lens implantation in dogs: 32 cases. *J Vet Sci* 2006;7:281-285.
11. Fine IH: Corneal tunnel incision with a temporal approach. In: Fine IH, Fichman RA, Grabow HB, eds. *Clear Corneal Cataract Surgery and Topical Anesthesia*. Thorofare, NJ: Slack; 1993:5-26.
12. Gimbel HV: Principles of nuclear phacoemulsification. In: Steinert RF, ed. *Cataract Surgery: Technique, Complication, and Management*. 2nd ed. Philadelphia, PA: Saunders, An imprint of Elsevier Science; 2004:153-181.
13. Ernest PH, Kiessling LA, Lavery KT: Relative strength of cataract incisions in cadaver eyes. *J Cataract Refract Surg* 1991;17(Suppl):668-671.
14. Ernest PH, Fenzl R, Lavery KT, Sensoli A: Relative stability of clear corneal incisions in a cadaver eye model. *J Cataract Refract Surg* 1995;21:39-42.
15. Koch PS: Structural analysis of cataract incision construction. *J Cataract Refract Surg* 1991;17(Suppl):661-667.
16. Nelms SR, Davidson MG, Nasisse MP, Glover TL: Comparison of corneal and scleral surgical approaches for cataract extraction by phacoemulsification and intraocular lens implantation in normal dogs. *Prog Vet Comp Ophthalmol* 1994;4:53-60.
17. Williams DL, Boydell IP, Long RD: Current concepts in the management of canine cataract: a survey of techniques used by surgeons in Britain, Europe and the USA and a review of recent literature. *Vet Rec* 1996;138(15):347-353.
18. Biros DJ, Gelatt KN, Brooks DE, et al: Development of glaucoma after cataract surgery in dogs: 220 cases (1987-1998). *J Am Vet Med Assoc* 2000;216:1780-1786.
19. Chahory S, Clerc B, Guez J, Sanna M: Intraocular pressure development after cataract surgery a prospective study in 50 dogs (1998-2000). *Vet Ophthalmol* 2003;6:105-112.
20. Murphy CJ, Zandnik K, Mannis MJ: Myopia and refractive error in dogs. *Invest Ophthalmol Vis Sci* 1992;33:2459-2463.
21. Davidson MG, Murphy CJ, Nasisse MP, et al: Refractive state of aphakic and pseudophakic eyes of dogs. *Am J Vet Res* 1993;54:174-177.
22. Lannek EB, Miller PE: Development of glaucoma after phacoemulsification for removal of cataracts in dogs: 22 cases (1987-1997). *J Am Vet Med Assoc* 2001;218:70-76.