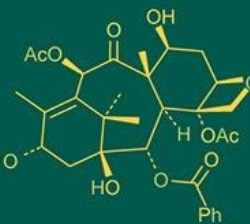
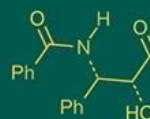
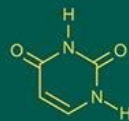
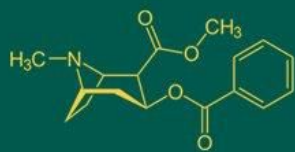


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Evaluation of Superficial Keratectomy with Medial Canthoplasty as a Treatment Modality for Pigmentary Keratitis in Pugs: A Surgical Interventional Study

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Abstract

Aim: To study the efficacy of superficial keratectomy with medial canthoplasty as a therapeutic modality for pigmentary keratitis (PK) in pugs.

Place and Duration of Study: Department of Veterinary Surgery and Radiology, College of Veterinary Science, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab, India during the year 2020-21.

Methodology: This study was conducted on six (n=6) eyes of six Pug breed of dogs presented to the clinics with signs of poor vision. All the animals were subjected to complete ophthalmic examination and clinically diagnosed for Pigmentary Keratitis. Superficial keratectomy with medial canthoplasty was performed under general anaesthesia in all the cases and their outcomes were assessed.

Results: All the animals included in the study were adults (3 to 7 years) with five males and one female animal. The mean age of the study population was 5.33 ± 0.25 years. All six (100%) animals exhibited Medial Caruncular Trichiasis (MCT), four (66.67%) animals exhibited Medial Entropion of Lower Eyelid (MELE) and two (33.33%) animals exhibited Keratoconjunctivitis sicca (KCS). The preoperative mean pigmentation score, mean Schirmer's tear test (STT) value and the mean intraocular pressure (IOP) was 14.0 ± 0.00 , 10.75 ± 2.84 mm/min and 21.4 ± 2.80 mm Hg, respectively. The menace response was positive in three animals and negative in three animals preoperatively. Superficial keratectomy and medial canthoplasty was performed concurrently in all six animals and a shortening of the unstretched palpebral fissure length by 0.4-0.5 cm in comparison to the contralateral eye was observed. The mean pigmentation score on the 60th postoperative day was 13.5 ± 0.5 . The menace response was positive in two animals on the 120th postoperative day.

Conclusion: The positive visual outcomes of superficial keratectomy performed concurrently with medial canthoplasty was short-lived, with the repigmentation of the cornea as the major postoperative concern

Keywords: Eye, pigmentary keratitis, superficial keratectomy, medial canthoplasty, pugs

1. Introduction

Corneal affections in brachycephalic breed of dogs constitute the major share of ocular ailments and pigmentary keratitis being the most common corneal affection followed by corneal ulcers (Amol, 2016) [2]. Pigmentary keratitis or corneal melanosis is one of the most common ocular ailment reported in the pugs and affectionately termed as 'Pugmentary keratitis' to mark the higher rate of incidence in the pug breed of dogs (Appelboom, 2016) [4]. Pigmentary keratitis is a mere clinical sign resulting as a response to the chronic inflammatory process incited by various ocular ailments contributing to the migration of the melanocytes into the superficial corneal epithelium or into the deep corneal stroma (Westermeyer *et al.*, 2009) [16].

Pigmentary keratitis may develop as a feature of various corneal affections that are inflammatory such as keratoconjunctivitis sicca (KCS), chronic superficial keratitis (pannus) and chronic ulcerative/nonulcerative keratitis (Maini *et al.*, 2019) [12]. Corneal melanosis may also develop as a sequel to the corneal trauma as a part of the wound-healing response usually preceded and accompanied by corneal vascularization and fibrosis (Kaswan *et al.*, 1989) [8]. Insufficient or a delayed medical management may lead to progressive loss of vision in animals due to the progressive migration of the melanocytes and pigmentation of the cornea.

Medical management of pigmentary keratitis has its own benefits in slowing down the progression of melanocytes but the root inciting causes for corneal irritation and inflammation such as entropion, distichiasis, trichiasis and medial caruncular trichiasis require surgical interventions in order to eliminate the inciting causes and cease the further progression of the pigmentation. Surgical intervention such as superficial keratectomy is warranted in cases of chronic superficial keratitis with heavily pigmented cornea (Wilkie & Whittaker, 1997) ^[17]. Medial canthoplasty is a corrective surgical procedure usually performed in the brachycephalic breed of dogs to address the brachycephalic ocular syndrome and medial entropion of lower eyelids (Bettenay *et al.*, 2018) ^[6]. Considering the higher rate of incidence and clinical significance of the pigmentary keratitis, this study was conducted to evaluate the efficacy of superficial keratectomy performed concurrently with medial canthoplasty to improve the quality of vision and thereby the quality of life of the animals.

2. Materials and Methods

2.1. Study Population & Method

The study was conducted on six (n=6) eyes of six Pug breed of dogs presented to the Department of Veterinary Surgery and Radiology, GADVASU, Ludhiana with the presenting signs of poor ambulation and deteriorating vision. Detailed anamnesis with age, sex and other identification details were recorded in each case. Each animal was subjected to a detailed ophthalmic examination performed in a consistent and sequential manner following a step-by-step approach to establish a diagnosis as described by Maggs, (2018) ^[11].

The ophthalmic examination includes gross ophthalmic examination, behavioral assessment of the vision with cotton ball test and maze test, neuro ophthalmic tests or reflexes such as palpebral reflex, menace response, pupil symmetry, pupillary light reflex (PLR) and dazzle reflex and special diagnostic procedures such as Schirmer's tear test, fluorescein dye test, rose bengal dye test, tonometry, slit lamp bio-microscopy, ophthalmoscopy (Direct and Indirect) and ultrasonography.

Whole blood samples were collected for routine preoperative blood work up to assess the physiological status of the animals and their suitability for anesthesia and surgical intervention. The animals were categorized based on their age into young animals (0 to 3 years), adult animals (3 to 7 years) and senile animals (above 7 years). The pictures of the eyes were taken to study the severity and pattern of pigmentation after rinsing the eyes with sterile 0.9% normal saline solution. The severity and pattern of pigmentation were assessed using the methods suggested by Maini *et al.*, (2019) ^[12] and Charbiwala, (2019) ^[7], respectively.

2.2. Preoperative medicinal therapy

Preoperative medications included topical ocular administration of carboxy methyl cellulose sodium (0.5%), gatifloxacin (0.3%) and cyclosporine (0.1%) from the day of presentation till the scheduled date of surgery. Preoperative medications also included systemic antibiotics, Non-Steroidal Anti-Inflammatory Drugs (NSAIDs) and other supplements on case to case basis depending upon the results of the preoperative blood screening. Gatifloxacin (0.3%) was administered in intervals of 15 to 20 minutes on both eyes starting from an hour prior to the commencement of the surgery to ensure ocular aseptis.

2.3. Anaesthesia

Anaesthetic protocol included Butorphanol @ 0.2 mg/kg body weight, Atropine @ 0.02 - 0.04 mg/kg body weight and Acepromazine maleate @ 0.02 - 0.05 mg/kg body weight (included on case to case basis) as premedication by intramuscular route. Systemic antibiotics Cefotaxime @ 25 mg/kg body weight and NSAIDs Meloxicam @ 0.2 mg/kg body weight were also administered as a part of premedication by intravenous route. The animals were induced with Propofol @ 4 mg/kg body weight and Diazepam @ 0.5 mg/kg body weight administered slowly by intravenous route and the surgical plane of anaesthesia was maintained using Isoflurane.

2.4. Patient positioning and preparation

Patients were placed in lateral recumbency with the affected eye on the dorsal side and the head was positioned for the convenience of the surgeon using padding materials under the head. The eyelids and the periorbital area were trimmed of the hairs and 5% povidone iodine solution was used to paint the surgical site. A 0.5% solution of povidone iodine was used to flush the dorsal and ventral conjunctival fornix before the commencement of surgery.

2.5. Operating Procedure

Under anaesthesia, a Lieberman speculum and traction sutures with 3-0 vicryl were used to secure the eye in position and to retract the eyeballs rotated ventro-medially from the bony orbit. An incision was made at the level of limbus using Beaver blade No.6400 encircling the cornea or a section of it depending upon the severity and extent of corneal pigmentation (Fig.1A). As the corneal incision was performed, a continuous stream of 0.9% normal saline was directed at the leading aspects of the corneal incision and the depth of the incision was made sufficient enough to remove the base of the pigmented cornea.

Once the corneal incision was made sufficient enough to encircle the pigmentation, a colibri or lim's forceps was used to grasp the edge of the superficial keratectomy section and the pigmented corneal epithelium was carefully dissected from the underlying corneal stroma (Fig.1B). Care was taken throughout the procedure by holding the Beaver blade tangential to the corneal surface to limit the dissection of the pigmented corneal epithelium under one lamellar plane and to avoid progressive deeper dissection into the corneal stroma (Fig.1C). However, excision of corneal epithelium was performed along with a variable amount of corneal stroma due to the varying depths of corneal pigmentation and stronger attachment of the pigmented corneal epithelium to varying depths of underlying stroma. The pupil can be visualized on removal of the pigmented corneal epithelium (Fig.1D & 1E). Once the entire area of pigmented corneal epithelium was excised by performing superficial keratectomy, medial canthoplasty was performed. The corneal surface was lavaged at regular intervals using a stream of 0.9% normal saline while performing medial canthoplasty.

Medial canthoplasty was performed in all six animals concurrently with superficial keratectomy. The medial caruncle was revealed by rolling out the medial canthus in the direction of the nostrum and the upper and lower nasolacrimal puncta were identified and cannulated with the help of a nasolacrimal cannula to avoid inadvertent damage to the puncta and the ducts during surgery (Fig.2A). The

triangular area of tissue to be excised was identified and a skin incision was made around the medial canthus to delineate the portion of medial caruncle and eyelid margins to be removed (Fig.2B). The dissection and excision of the triangular tissue section was performed with the help of a tenotomy scissors taking care not to damage the puncta and ducts. Any remaining hair or its follicle was excised delicately (Fig.2C).

A two-layer closure of the surgical site was performed. The deep conjunctival layer was sutured with 6-0 Vicryl in a simple continuous pattern, with knots buried to minimize corneal irritation (Fig.2D). The skin closure was done using 5-0 Nylon, performing a figure-of-eight suture pattern for the skin of the medial canthus and simple interrupted sutures for the remaining section of the skin, incorporating the tags of the figure-of-eight suture into the interrupted sutures to prevent corneal irritation (Fig.2E & 2F). On completion of both the operating procedures, a temporary partial tarsorrhaphy was performed using 2-0 Nylon leaving sufficient space for administration of topical ocular medications. The tarsorrhaphy sutures were removed after 15 days in all the animals to study the surgical outcome.

2.6. Postoperative care

Postoperative care included intramuscular administration of systemic antibiotics (Cefotaxime @ 25 mg/kg body weight, b.i.d. for 5 days), NSAIDs (Meloxicam @ 0.2 mg/kg body weight, o.d. for 3 days) and topical ocular administration of NSAIDs (0.5% Ketorolac tromethamine, q.i.d for 4 days), lacrimomimetics (0.5% Carboxy methyl cellulose sodium, q.i.d for 1 month) and antibiotics (0.3% Gatifloxacin, q1h in 1st week, q2h in 2nd week, q3h in 3rd week and q4h in 4th week). Cyclosporine (0.1%) was included in the postoperative treatment only when the fluorescein dye test results turned negative during the follow up. The efficacy of the treatment protocol was evaluated by assessing all the animals clinically at regular intervals wherever possible with respect to healing, restoration of vision and complications. The restoration of the vision was assessed using menace response and a positive menace response postoperatively was considered as a sign of restoration of vision provided that the corneal lesions did not affect the visual axis pathway of the animal. The data were analyzed using appropriate statistical methods wherever applicable.

3. Results

Mean age of the animals that underwent the surgical protocol was 5.33 ± 0.25 years (4.5 to 6 years) and all the animals were in the adult category (3 to 7 years). Out of the six animals that were included in the study, five were male (83.33%) and one was a female (16.67%) animal. In addition to various clinical signs such as episcleritis, conjunctivitis, corneal and conjunctival pigmentation, corneal edema, neovascularization and corneal fibrosis, all six (100%) animals exhibited Medial Caruncular Trichiasis (MCT), four (66.67%) animals exhibited Medial Entropion of Lower Eyelid (MELE) and two (33.33%) animals exhibited Keratoconjunctivitis sicca (KCS). The mean pigmentation grading score was 14.0 ± 0.00 with a diffuse pattern of pigmentation in five animals and a patchy pattern of corneal pigmentation in one animal (Fig.3A). In neuro ophthalmic reflexes, a positive palpebral reflex was observed in all six animals, the pupillary light reflex was not appreciable in all six animals due to the corneal pigmentation and menace

response was positive in three animals and negative in three animals, respectively. The mean Schirmer's tear test (STT) value of the animals was 10.75 ± 2.84 mm/min and the mean intraocular pressure (IOP) was 21.4 ± 2.80 mm Hg. All six animals had a negative fluorescein dye test and five out of the six animals had a positive rose bengal dye test. On ultrasonography, one animal out of the six exhibited changes in the lens indicative of cataract and no other ultrasonographic structural abnormalities were observed (Table 1).

Superficial keratectomy procedure was performed in all six animals with relative ease in comparison to the medial canthoplasty due to the macropalpebral fissure and lagophthalmos conditions of the brachycephalic breeds. Challenges such as limited operating space at the medial canthus, difficulty in cannulation of the lower punctum were encountered, primarily due to prominent nasal folds and medial entropion of lower eyelids associated with the lower craniofacial ratio in brachycephalic breeds.

Major clinical findings postoperatively included opacity of the axial cornea with hyperaemic crests circumscribing the peripheral cornea at the level of the limbus on the 15th postoperative day (Fig.3C) and corneal ulceration in concurrence with corneal fibrosis/scarring, neovascularization and hyperaemic crests on the 30th postoperative day (Fig.3D). Recurrence of the pigment was observed in 4 animals after the 30th postoperative day progressing from the medial canthus and along the limbus in a circumferential pattern, extending into the peripheral cornea while two animals had a complete corneal repigmentation concurrently with corneal ulcer on the 45th postoperative day (Table 2). The healing of the medial canthoplasty surgical wound was observed to be sufficient and a shortening of the unstretched palpebral fissure length by 0.4-0.5 cm in comparison to the contralateral eye was observed.

Complete healing of the corneal ulcer with mild neovascularization, opacity and fibrosis was observed in the four animals that were followed up 60 days after the surgery with the pigmentation seen progressing into the axial cornea. The mean pigmentation score on the 60th postoperative day was 13.5 ± 0.5 , almost similar to that observed preoperatively. In the animals that were followed up 120 days after the surgery, corneal transparency was observed with apparently no corneal scarring or fibrosis, mild neovascularization and opacity. Though these animals had a positive visual outcome, the progression of the corneal pigmentation continued with the pigmentation covering more than 75 percent of the cornea, suggesting recurrence of the pigmentation as the major postoperative complication of superficial keratectomy. A positive menace response was observed only in two of the six animals on the 120th postoperative day.

4. Discussion

All the animals included in the study were adults above the age of 4 years indicating the lack of awareness among the owners about the condition resulting in the animals being presented only in the later stages of pigmentation. The majority of the animals presented in the study were males, indicating a higher rate of distribution among the males consistent with the findings of Krecny *et al.*, (2015) [9] and contrary to the findings of Azoulay, (2014) [5], Allgoewer & Hoecht, (2010) [11] and Petersen-Jones *et al.*, (2007) [14]. All the animals in the study had MCT while most of the animals had MELE and few animals had KCS concurrently with corneal

pigmentation consistent with the findings of Maini *et al.*, (2019)^[12] and contrary to the findings of Krecny *et al.*, (2015)^[9]. The mean STT value of the animals included in the study was below the normal range contrary to the findings of Maini *et al.*, (2019)^[12].

The mean IOP of the animals of this study was within the normal range consistent with the findings of Vallone *et al.*, (2017)^[15] and contrary to the findings of Anoop *et al.*, (2016)

^[3]. The postoperative findings such as neovascularization, corneal opacity and fibrosis observed in this study were similar to those reported by Peiffer *et al.*, (1976)^[13]. The success rate of the surgical protocols in this study was limited by the recurrence of the corneal pigmentation and corneal scarring, findings that are consistent with those reported by Ledbetter & Gilger, (2013)^[10].

Table 1: Summary of the preoperative observations in animals

Case No.	Age (years)	Sex	Eye	Etiology	Ocular Discharge	Extent of Pigmentation	Pattern of Pigmentation	Severity of Pigmentation	Pigmentation Score	Duration of Pigmentation	Menace Response	PLR	Palpebral Reflex	USG Findings
A	6.0	Male	Right	MELE, MCT, KCS	Mucopurulent	Complete	Diffuse	Severe	14	2 years	-ve	NA	+ve	NAD
B	5.0	Male	Left	MELE, MCT	Mucoid	Complete	Diffuse	Severe	14	3 months	-ve	NA	+ve	NAD
C	5.5	Male	Right	MCT	Mucoid	Complete	Diffuse	Severe	14	6 months	+ve	NA	+ve	NAD
D	6.0	Female	Right	MELE, MCT	Mucoid	Complete	Diffuse	Severe	14	2 years	Mild +ve	NA	+ve	Cataract
E	5.0	Male	Left	MELE, MCT, KCS	Mucopurulent	Complete	Diffuse	Severe	14	2 months	+ve	NA	+ve	NAD
F	4.5	Male	Right	MCT	Mucopurulent	Medial	Patchy	Severe	14	3 months	-ve	NA	+ve	NAD

Table 2: Summary of the postoperative observ

Case no	Postoperative (Day 15)	Postoperative (Day 30)	Postoperative (Day 45)	Postoperative (Day 60)	Postoperative (Day 120)
A	Corneal opacity, hyperaemic crest	-	Corneal ulcer & fibrosis, hyperaemic crest, re-pigmentation	Corneal ulcer healed, fluorescein staining (-ve), progressive pigmentation, neovascularisation, (Menace - ve)	-
B	Corneal opacity, hyperaemic crest	-	Re-pigmentation of entire cornea, (Menace - ve)	-	-
C	Corneal opacity, hyperaemic crest	-	Re-pigmentation of entire cornea, (Menace - ve)	-	-
D	Corneal opacity, hyperaemic crest	Corneal fibrosis, hyperaemic crests, re-pigmentation	-	Complete corneal healing, progressive pigmentation, neovascularisation, (Menace - ve)	-
E	Corneal opacity, hyperaemic crest	Corneal fibrosis & ulcer, neovascularisation, fluorescein staining (+ve), re-pigmentation	-	Corneal ulcer healed, fluorescein staining (-ve), progressive pigmentation, neovascularisation,	Corneal transparency observed, mild opacity, neovascularisation, > 75% cornea pigmented, (Menace + ve)
F	Corneal opacity, hyperaemic crest	-	Corneal fibrosis, hyperaemic crest, re-pigmentation	Complete corneal healing, progressive pigmentation, neovascularisation,	Corneal transparency observed, mild opacity, > 75% cornea pigmented, (Menace + ve)

Plate 1: Superficial Keratectomy

Fig 1A: Partial thickness corneal incision made at the limbus with Beaver blade No.6400, **(B)** Meticulous excision of pigmented corneal epithelium

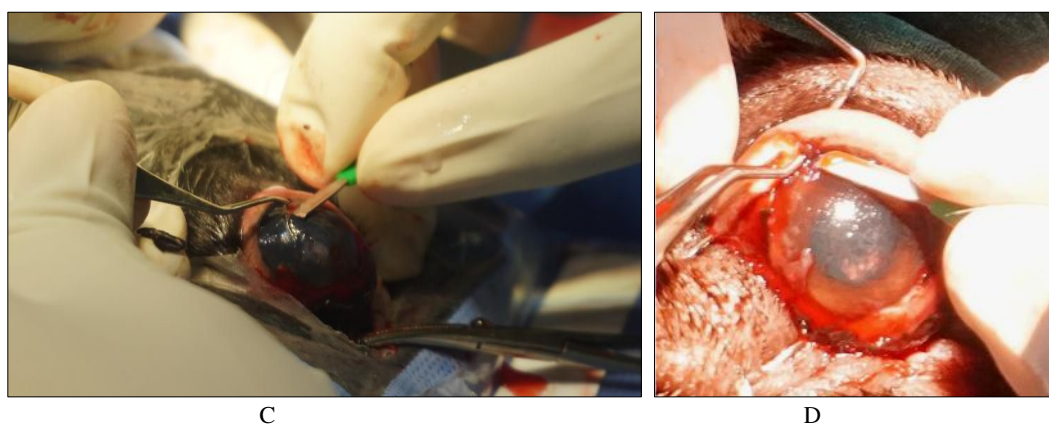


Fig 1C: Beaver blade held tangential to the corneal surface to prevent progressive deeper dissection, **(D)** Pupil visible as the pigmented epithelium is excised



Fig 1E: Transparent cornea immediately after superficial keratectomy

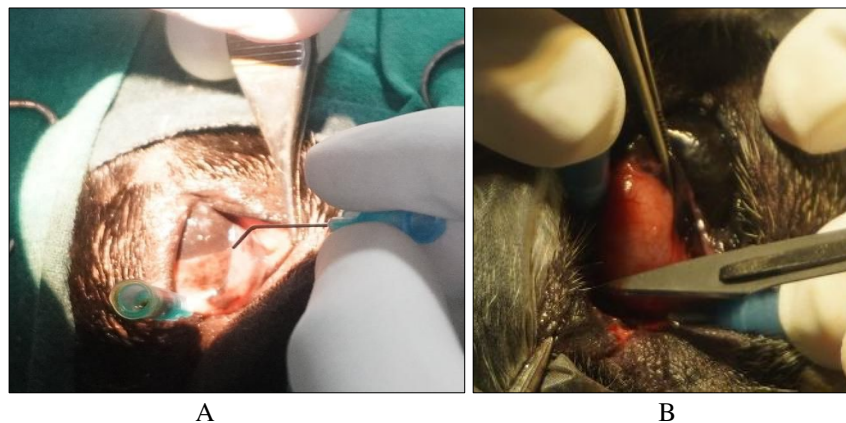
Plate 2: Medial Canthoplasty

Fig 2A: Cannulation of lacrimal puncta, **(B)** Incision being made at the medial canthus

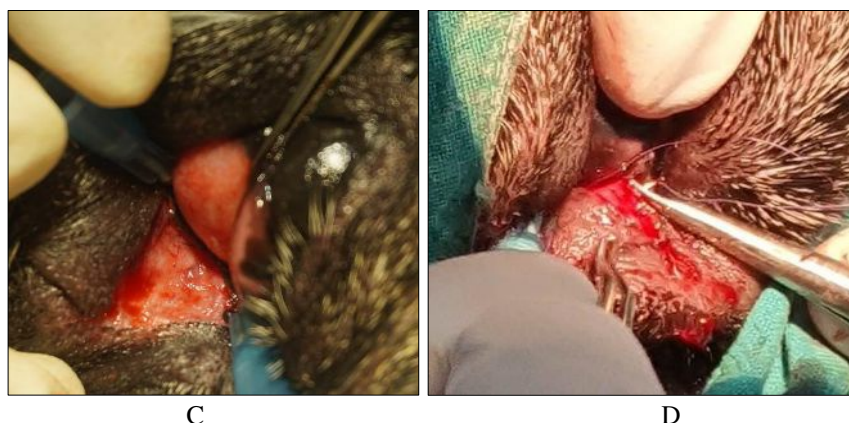


Fig 2C: Triangular area of tissue excised along with the caruncle, **(D)** Suturing the deep conjunctival layer with 6-0 vicryl

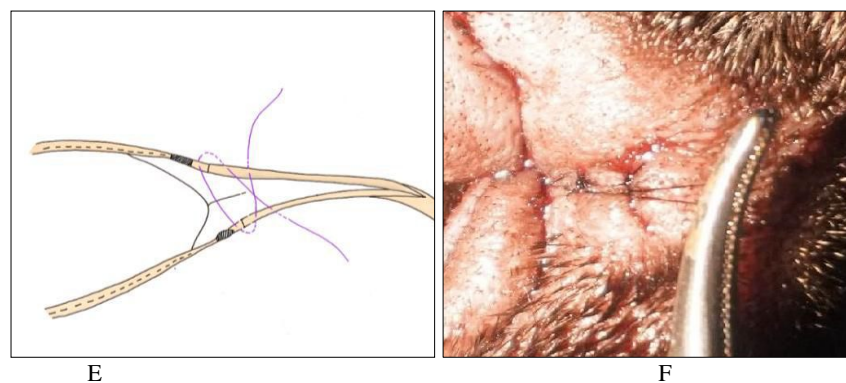


Fig 2E: Figure-of-8 suture pattern illustration **(F)** Tags of figure-of-8 skin suture incorporated in the subsequent interrupted sutures

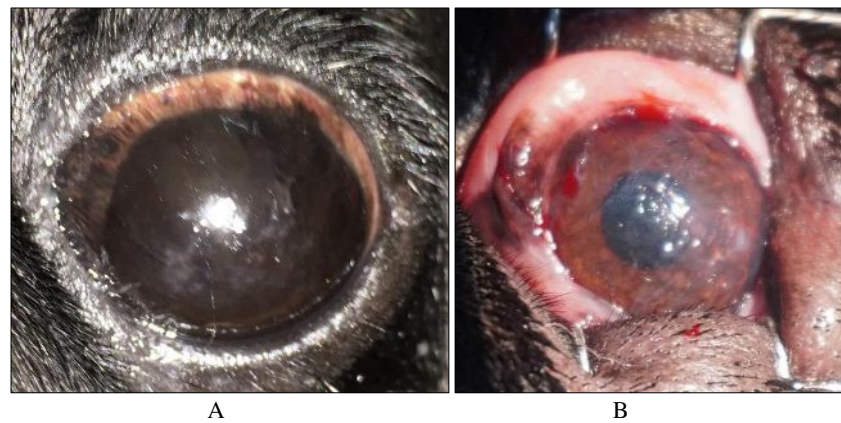
Plate 3: Preoperative, Intraoperative and Postoperative eye images of Case E

Fig. 3A: Pre-operative - Complete diffuse pigmentation of cornea, **(B)** Intraoperative - Immediately after Superficial Keratectomy (Pupil can be visualized)

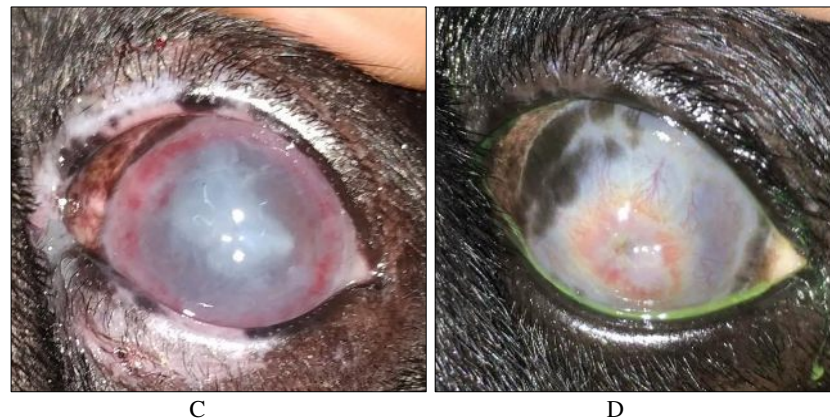


Fig 3C: Postoperative Day 15 - Corneal opacity and hyperaemic crest **(D)** Postoperative Day 30 - Corneal fibrosis, neovascularization, corneal ulcer (Positive for fluorescein dye test) and recurrence of pigmentation

5. Conclusion

The study aimed to evaluate the efficacy of superficial keratectomy performed concurrently with medial canthoplasty as a treatment modality for addressing the pigmentary keratitis in pugs and the findings of the study suggest that the positive visual outcomes of the surgical interventions are short lived with the success rate limited by the recurrence of pigmentation as the major postoperative complication.

6. Acknowledgements

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7. Competing interests

The authors have no conflict of interest/ competing interests.

8. Authors' Contributions

Rajasekaran Tiruppur Manikumar & Shashi Kant Mahajan designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Nameirakpam Umeshwori Devi managed the analyses of the study. Jasmeet Singh Khosa & Arun Anand managed the literature searches. All authors read and approved the final manuscript.

References

1. Allgoewer I, Hoecht S. Radiotherapy for canine chronic superficial keratitis using soft X-rays (15 kV). *Vet Ophthalmol.* 2010;13(1):20-25. DOI:10.1111/j.1463-5224.2009.00750.x.
2. Amol PE. Studies on the incidence, diagnosis and management of different ocular affections in brachycephalic dogs [dissertation]. 2016. p. 1.
3. Anoop S, Devanand CB, Syam KV, JM KD, ARAG KN, Gleeja L. Pigmentary keratitis in dogs - a study on incidence in 83 corneas. *Malays J Vet Res.* 2016;7(1):15-20.
4. Appelboom H. Pug appeal: brachycephalic ocular health. *Companion Anim.* 2016;21(1):29-36. DOI:10.12968/coan.2016.21.1.29.
5. Azoulay T. Adjunctive cryotherapy for pigmentary keratitis in dogs: a study of 16 corneas. *Vet Ophthalmol.* 2014;17(4):241-249. DOI:10.1111/vop.12089.
6. Bettenay S, Mueller RS, Maggs DJ. Diseases of the eyelids. In: Maggs DJ, Miller PE, Ofri R, editors. *Slatter's fundamentals of veterinary ophthalmology*. 6th ed. St. Louis (MO): Elsevier; 2018. p. 141-142.
7. Charbiwala MK. Ocular affections in animals with particular reference to corneal melanosis [master's thesis]. Palampur (HP): Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya; 2019. Available from: Krishikosh.
8. Kaswan RL, Salisbury MA, Ward DA. Spontaneous canine keratoconjunctivitis sicca: a useful model for

- human keratoconjunctivitis sicca—treatment with cyclosporine eye drops. *Arch Ophthalmol.* 1989;107(8):1210-1216.
9. Krecny M, Tichy A, Rushton J, Nell B. A retrospective survey of ocular abnormalities in pugs: 130 cases. *J Small Anim Pract.* 2015;56(2):96-102. DOI:10.1111/jsap.12291.
 10. Ledbetter EC, Gilger BC. Diseases and surgery of the canine cornea and sclera. *Vet Ophthalmol.* 2013;2:976-1049.
 11. Maggs DJ. The ophthalmic examination and diagnostic testing. In: Maggs DJ, Miller PE, Ofri R, editors. *Slatter's fundamentals of veterinary ophthalmology.* 6th ed. St. Louis (MO): Elsevier; 2018. p. 18-50.
 12. Maini S, Everson R, Dawson C, Chang YM, Hartley C, Sanchez RF. Pigmentary keratitis in pugs in the United Kingdom: prevalence and associated features. *BMC Vet Res.* 2019;15(1):384. DOI:10.1186/s12917-019-2127-y.
 13. Peiffer RL, Gelatt K, Gwin R. Superficial keratectomy in the management of indolent ulcers of the boxer cornea. *Canine Pract.* 1976;3(4):31-33.
 14. Petersen-Jones SM, Forcier J, Mentzer AL. Ocular melanosis in the Cairn Terrier: clinical description and investigation of mode of inheritance. *Vet Ophthalmol.* 2007;10(Suppl 1):63-69. DOI:10.1111/j.1463-5224.2007.00558.x.
 15. Vallone LV, Enders AM, Mohammed HO, Ledbetter EC. In vivo confocal microscopy of brachycephalic dogs with and without superficial corneal pigment. *Vet Ophthalmol.* 2017;20(4):294-303. DOI:10.1111/vop.12416.
 16. Westermeyer HD, Ward DA, Abrams K. Breed predisposition to congenital alacrima in dogs. *Vet Ophthalmol.* 2009;12(1):1-5. DOI:10.1111/j.1463-5224.2009.00665.x.
 17. Wilkie DA, Whittaker C. Surgery of the cornea. *Vet Clin North Am Small Anim Pract.* 1997;27(5):1067-1107.