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Optical coherence tomographic evaluation of deep corneal ulcers healing treated by corneo-conjunctival transposition graft and conjunctival bridge graft in dogs

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Twelve dogs with deep corneal ulcers were treated using corneo-conjunctival transposition (CCT) grafting in six dogs and conjunctival bridge grafting in the remaining six. CCT grafting demonstrated a significantly shorter surgical duration compared to conjunctival bridge grafting. Comprehensive pre- and post-operative assessments, including ophthalmic, neuro-ophthalmic, and behavioural vision evaluations, were conducted over a 120-day period. Dogs that underwent CCT grafting exhibited a more rapid restoration of vision, attaining near corneal transparency by day 90, whereas those treated with conjunctival bridge grafting achieved similar transparency by day 120. Optical coherence tomography (OCT) confirmed excellent corneal healing and graft integration in both groups. A single case of graft dehiscence was observed on postoperative day 5 in the conjunctival bridge graft group. In conclusion, CCT grafting emerged as the superior approach, offering expedited corneal transparency, enhanced visual recovery, and a reduced surgical duration compared to conjunctival bridge grafting.

***Key words**: Dogs, Conjunctival bridge graft, Corneo-conjunctival transposition (CCT) graft, Optical coherence tomography (OCT)*

Corneal ulceration results from a disruption in the corneal epithelium, exposing the underlying stroma. Clinically, it manifests with excessive lacrimation, blepharospasm, photophobia, conjunctival hyperemia, corneal oedema and in severe cases, miosis and aqueous flare. Diagnosis was made based on these clinical signs, confirmed by fluorescein dye retention in the corneal stroma (David Whitley and Hamor, 2021).

Corneal ulcers are classified by depth and etiology, ranging from superficial to stromal ulcers, descemetoceles and perforations. The superficial ulcers heal rapidly with minimal scarring, while deep ulcers involving infection, develop visual impairment due to corneal scarring. Perforated ulcers leads to anterior synechiae formation, and severe ulcerative keratitis; the risk of ocular loss develops from complications such as endophthalmitis and glaucoma (David Whitley and Hamor, 2021).

Superficial ulcers typically resolve within a week with topical antibiotics, artificial tears and mydriatic agents (Wilkie and Whittaker, 1997; Maggs, 2008). However, stromal ulcers progress rapidly, often leading to stromal melting and potential descemetocele formation. If Descemet's membrane ruptures, it may result in ocular perforation and iris prolapse, which significantly worsen the prognosis (Maggs, 2008).

Surgical intervention is necessary when corneal involvement exceeds 50% of its thickness, aiming to stabilize the cornea and prevent further stromal loss (David Whitley and Hamor, 2021). Treatment options include third eyelid membranoplasty, conjunctival grafts, corneo-conjunctival transposition (CCT), amniotic membrane transplantation and bioengineered corneal grafts (Wilkie and Whittaker, 1997).

The conjunctival bridge graft, a bipedicle technique, is beneficial for persistent linear corneal lesions requiring vascularization, particularly in central corneal defects (David Whitley and Hamor, 2021). In contrast, CCT utilizes a sliding autologous corneo-scleral graft to repair corneal defects, making it ideal for central, deep, or perforated ulcers when sufficient peripheral cornea is available (Parshall, 1973). By using autologous tissue, CCT reduces immune-mediated reactions and minimizes corneal scarring, offering superior postoperative clarity compared to conjunctival grafting and other techniques. In this study, corneo-conjunctival transposition graft and conjunctival bridge graft were evaluated in healing of deep corneal ulcers in dogs by optical coherence tomography.

Materials and Methods

Twelve dogs with corneal ulcers reported from January 2019 to December 2023 were used in the

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study. All the patients underwent ophthalmic, clinical and diagnostic evaluations. The dogs were randomly assigned to two groups: group I (CCT) and group II (conjunctival bridge graft), based on the technique used for treatment. Preoperative and postoperative neuro-ophthalmic function and visual function tests, and STT were performed.

Fluorescein dye and optical coherence tomography were used for diagnosis of ulcer and ulcer depth assessment, respectively. The dogs slated for surgery were instilled with moxifloxacin and ketorolac eye drops (1 drop, four times daily) on the affected eye to maintain ocular asepsis. Extraocular asepsis was done by washing the eye with 0.5% povidone prior to the surgery.

All patients received preanaesthetics including glycopyrrolate (anticholinergic), dexmedetomidine (sedative) and butorphanol (analgesic). The induction of anaesthesia was achieved by intravenous administration of propofol. Anaesthesia was maintained with 1-2.5% isoflurane. The Barraquer wire speculum was placed over the eyelids, stay sutures were employed using silk No. 3-0 and end of the suture was anchored to the drape. The dimensions of the corneal ulcer were measured using a Castroviejo caliper. The ulcer was debrided with an ophthalmic diamond burr to remove all necrotic and collagenolytic tissues.

In group I, corneo-conjunctival transposition (CCT) grafting was performed. Two linear incisions, diverging from the ulcer to the limbus and extending into the bulbar conjunctiva at one half to two-thirds of the corneal thickness, were meticulously created. The graft was harvested from a more accessible direction. Lamellar keratectomy was performed using crescent blade ophthalmic knife (Fig.1). The conjunctival portion of the graft was undermined with Westcott scissors. The limbus part of the graft was sectioned with corneal scissors. Diluted epinephrine (1:1000) was applied topically to control excessive corneal and limbal bleeding. Meanwhile the corneal bed was also prepared to accommodate the graft using crescent blade ophthalmic knife. The corneo-conjunctival graft was then moved over the defect using castroveijo corneal forceps. First the leading margins were sutured into the corneal bed using absorbable polyglycolic acid No. 8-0 suture in a simple interrupted pattern. Later lateral margins were sutured into the corneal bed in a simple continuous pattern.

In group II, conjunctival bridge grafting was performed. A first incision was made on the bulbar conjunctiva using a B.P. blade No. 15, precisely 1-2 mm parallel to the limbus and extending to encompass 180° of conjunctiva (Fig. 2). Following this, a second incision was performed using B.P. blade No. 15 parallel to the first conjunctival incision. The bulbar conjunctival part

Fig. 1: Surgical procedure of corneo-conjunctival grafting: (a) lamellar keratectomy performed using crescent blade ophthalmic knife; (b) transposing the corneo-conjunctival graft; and (c) completed corneo-conjunctival transposition graft.

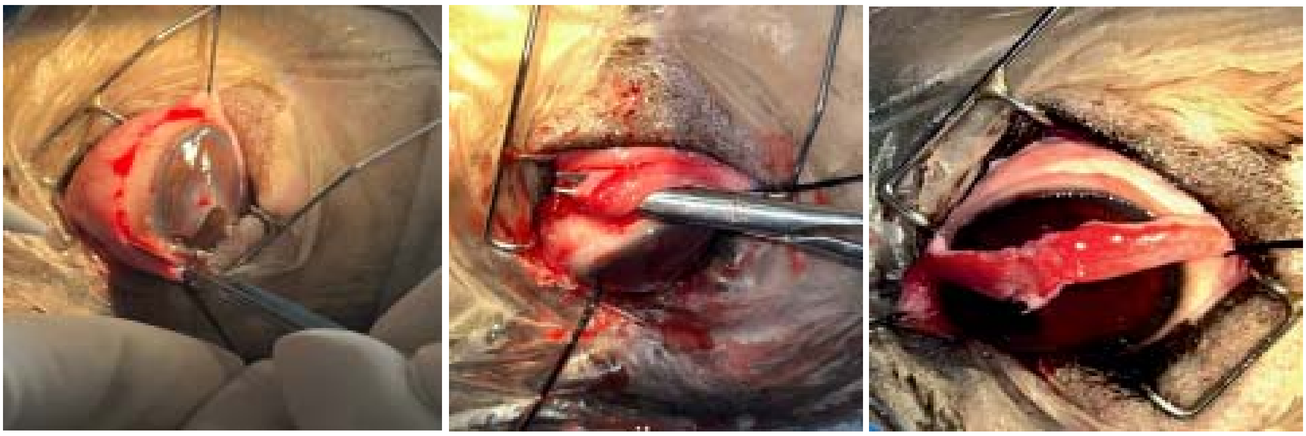

Fig. 2: Surgical procedure of conjunctival bridge grafting: (a) incision on bulbar conjunctiva; (b) undermining the bulbar conjunctiva between the two incisions using Westcott ý;scissors and (c) after completion of conjunctival bridge grafting.

of the graft was extensively undermined using Westcott scissors between these two parallel incisions. The resulting bridge was then moved over the ulcerated area using castroveijo corneal forceps. The graft was sutured to the ulcer edges of the cornea using absorbable No. 8-0 polyglycolic acid in a simple interrupted pattern. The defect that was formed in the bulbar conjunctiva was also sutured in a simple continuous pattern. The graft trimming was performed between 4 and 6 weeks after surgery to allow graft recession and reduce corneal scarring. The study was evaluated on day 0 before surgery and on days 15, 30, 45, 60, 90 and 120 by neuro-ophthalmic tests, vision function test, STT, FDT along with Optical Coherence Tomography (OCT).

Results and Discussion

The mean surgical duration recorded for group I was 60.67±1.54 min, whereas for group II, it was 103.17±2.73 min. The prolonged duration in group II was attributed to the complexity of its multi-step surgical procedure. Similar findings were reported by Milind (2021), who documented an average operating time of 68.66±3.66 min for CCT in canine corneal ulcer repair. Likewise, Vedpathak (2015) observed a mean operating time of 84.71±7.21 min in dogs undergoing a conjunctival pedicle graft.

Postoperatively, in group I, the corneo-conjunctival graft exhibited corneal opacity in five cases by day 15, which gradually diminished, achieving full corneal transparency by day 90. The conjunctival component demonstrated strong perfusion initially, which progressively reduced, with complete vascular regression by day 60. Sutures were visible by day 15 but fully absorbed by day 30. However, in one case, corneal transparency was restored earlier, by day 60. Milind (2021) similarly noted moderate postoperative corneal opacity by day 30, emphasizing that corneo-conjunctival transposition requires a prolonged observation period beyond one month due to its complexity.

In group II, the bridge graft demonstrated excellent adherence on days 15 and 30, with significant neovascularization in four cases. Mild corneal oedema was observed initially but resolved progressively, leading to corneal transparency by day 45, except at the graft-adhered site. Following graft trimming on day 45, the residual graft gradually dissolved, resulted in complete corneal transparency by day 120. In one case, mild corneal oedema was evident initially; however, transparency was achieved by day 30, except at the graft-adhered site, and after graft trimming on day 30, complete dissolution and transparency were observed by day 120. However, one case exhibited graft dehiscence by day 5 due to self-mutilation, leading to persistent mild corneal oedema on day 15. The oedema gradually subsided, though peripheral pigmentation and a moderate central corneal scar were noted by day 60. A mild epithelial scar persisted in all cases beyond day 120. Singh (2017) and Singh *et al.* (2022) reported comparable outcomes, documenting substantial corneal oedema on the 10th postoperative day, which significantly subsided by day 30. Their studies also highlighted corneal scarring and instances of graft dehiscence caused by self-mutilation. While the graft provided robust structural support, successful restoration of vision was achieved. Corneal clarity was attained earlier in group I compared to group II, with mild epithelial scarring persisting in group II at the final follow-up.

The Mean±SE values for Schirmer Tear Test (STT) measurements (mm/min) recorded preoperatively (day 0) and at intervals post-surgery (days 15, 30, 45, 60, 90 and 120 were as follows: in group I - 11.67±2.22, 13.83±1.97, 14.83±1.08, 16.67±0.99, 17.17±0.54, 17.17±0.75, and 17.67±0.33, respectively; and in group II - 10.67±2.09, 13.00±1.15, 14.00±1.34, 15.67±0.71, 16.83±0.75, 17.83±0.65, and 17.67±0.56, respectively. A statistically significant (Pd”0.05) increase in STT values was observed from day 45 to day 120 postoperatively in both groups. However, there was no significant difference in STT values between groups I and II, and both remained below normal physiological levels. The preoperative STT values indicated subnormal tear production, suggestive of keratoconjunctivitis sicca (KCS), which may have contributed to corneal ulceration. Postoperatively, STT values exhibited a positive trend, gradually approaching normal limits, likely due to the administration of carboxymethyl cellulose eye drops, which facilitated the restoration of tear production. Kim *et al.* (2009) similarly identified KCS as a predisposing factor for corneal ulceration.

Fluorescein dye tests were positive in all six eyes of both groups preoperatively. Postoperatively, fluorescein staining was observed at the base of sutures on day 15, but it was absent from day 30 onwards; however, in one case of group II, where mild stain uptake persisted on day 15. The initial stain uptake was attributed to fluorescein sodium binding to the exposed corneal stroma, effectively delineating the ulcer margins (Featherstone and Heinrich, 2021).

In group I, all cases exhibited only mild corneal opacity except for two dogs, one of the dogs was presented with moderate and the other with severe opacity. Opacity progressively diminished following surgery, with complete resolution by day 90 in all cases (Fig. 3). Conversely, in group II, all cases initially exhibited severe corneal opacity, except two dogs, which displayed moderate and mild opacity, respectively. While gradual improvement was noted postoperatively with complete corneal transparency by day 120 (Fig. 3), one case exhibited persistent moderate opacity at the final evaluation due to graft dehiscence and corneal fibrosis. These findings were consistent with the observations of Vedpathak (2015), Singh (2017), and Milind (2021).

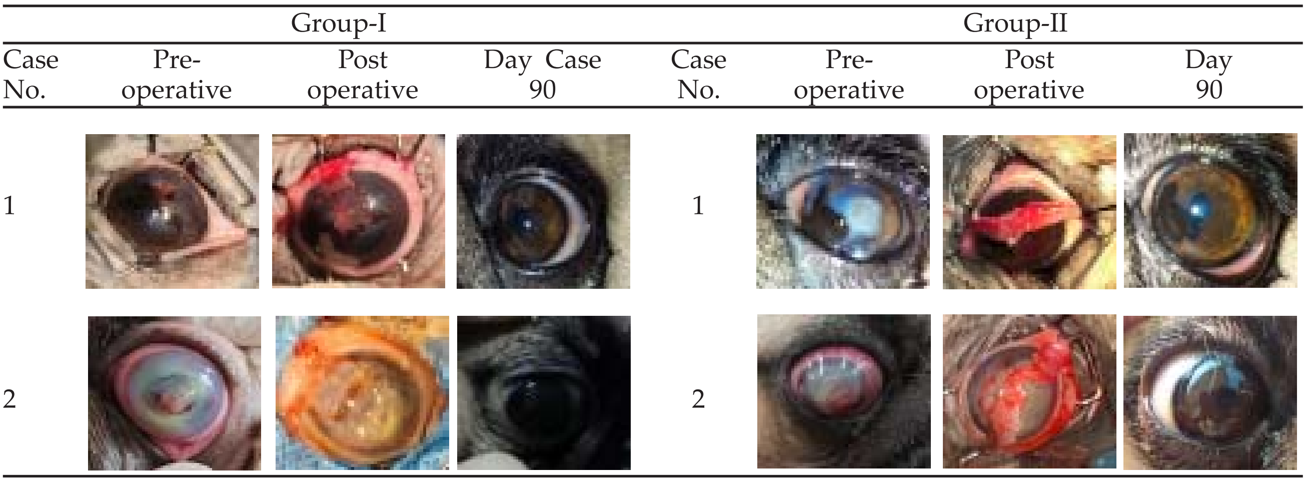

Fig. 3: Summary of the study.

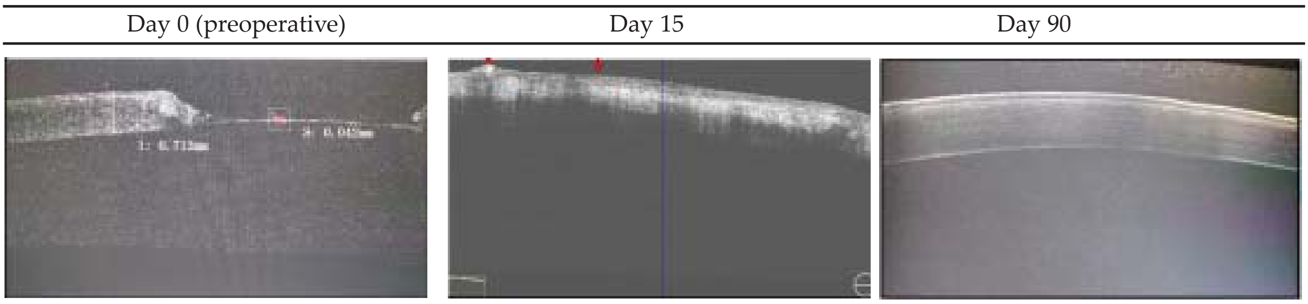

Fig. 4: OCT images of group I case showing healing with corneo-conjunctival transposition graft.

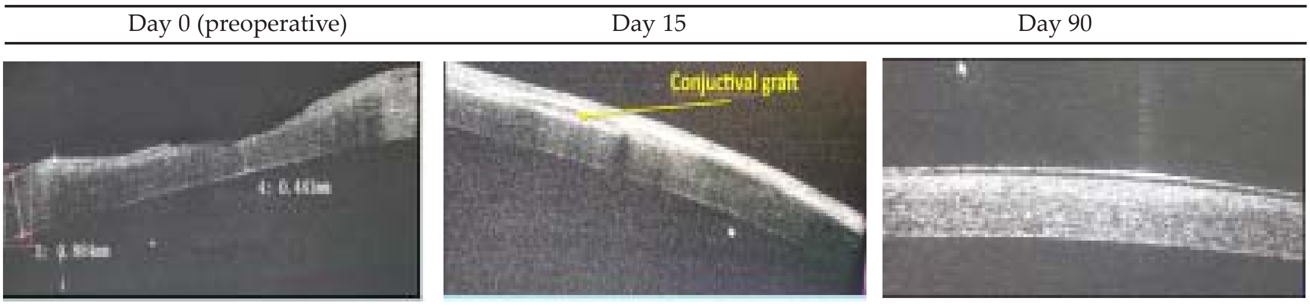

Fig. 5: OCT images of group II case showing healing with conjunctival bridge graft.

Corneal vascularization was noted in three cases in group I on day 0. By day 15, vascularization was observed in the conjunctival portion of the graft in all cases, which progressively regressed, with complete resolution by day 60. In group II, four cases exhibited corneal vascularization at day 0. Mild superficial vascularization persisted in three cases on day 15, which gradually regressed, with five cases showing no vascularization by day 90. However, one case demonstrated persistent mild superficial vascularization throughout the observation period. Similar findings were reported by Pot *et al.* (2014).

Optical coherence tomography (OCT) images confirmed successful corneal graft adherence in group I by day 15, progressing to a fully healed corneal stroma with clear structural integrity by day 90 (Fig. 4). In group II, excellent conjunctival graft adherence was noted by day 15, with discernible corneal structures visible by day 30 (Fig. 5). However, partial dissolution of graft material overlying the stroma was observed on day 60. By day 90, both groups exhibited clear corneal structures, though group II displayed a moderately homogeneous epithelial layer with mild residual haziness. One case in group II exhibited epithelial scarring and stromal fibrosis by day 30. These results align with the findings of Famose (2014), who has reported OCT images demonstrated conjunctival grafts encapsulated by an epithelial layer within the stromal framework.

The Mean±SE scores for corneal graft opacification at days 15, 30, 45, 60, and 90 in group I were 3.83±0.17, 2.83±0.17, 2.00±0.37, 1.17±0.31, and 0, respectively. Five cases exhibited severe opacity and one moderate opacity on day 15, with a gradual decline, leading to near-complete transparency by day 90. Comparable findings were reported by Gogova *et al.* (2020).

The postoperative period was characterized by excellent graft adherence in all group II cases, except for one instance (case 4), where graft dehiscence was observed on day 5, indicating suboptimal graft integration. Similar complications were noted by Vedpathak (2015) and Singh (2017). Graft perfusion was assessed at days 15, 30, and 45, revealing excellent perfusion in all cases except in case 3 and case 4, where perfusion was satisfactory on days 15 and 30 in case 3, whereas in case 4, graft dehiscence occurred as early as on day 5.

The sole postoperative complication in this study was observed in case 4 of group II, where bridge graft dehiscence resulted from self-mutilation. This complication led to significant scarring at the ulcer bed, impairing complete restoration of corneal transparency and slightly affecting vision. Similar complications have been reported by Singh (2017) and Singh *et al*. (2022).

The findings of the present study indicated that corneo-conjunctival transposition graft proved to be a comparatively superior technique to conjunctival bridge graft. This superiority was demonstrated by its reduced surgical operating time, enhanced postoperative recovery and improved visual outcomes. Additionally, it facilitated a more favorable resolution of corneal opacity, corneal oedema and neovascularization, leading to an earlier attainment of near-complete corneal transparency.

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