Various Application of Corneal Tattooing

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Abstract

Background: To evaluate the efficacy of corneal tattooing in a large case series.

Methods: The medical charts of 62 eyes of 62 patients who underwent corneal tattooing between March 2016 and August 2017 were retrospectively reviewed. The causes of opacity and various methods of corneal tattooing applied were analyzed.

Results: Among our 62 patients, 38 were male and 24 female. Average age was 48.47±15.30 (range, 12-74)years old. The mean follow-up period was 23.19 ±2.34 (range, 19-27) months. The most common causes of corneal opacity were ocular trauma (33 eyes, 53.2%), prior retinal surgery (9 eyes, 14.5%), congenital etiologies (8 eyes, 12.9%) and measles (5 eyes, 8.0%). The most common associated ocular findings were strabismus (23eyes, 37.0%), phthisis bulbi (17 eyes, 27.4%) and band keratopathy (13 eyes, 20.9%). Cosmetic outcomes improved without serious complications in all cases.

Conclusions: Corneal tattooing is a viable option with an expanding set of indications, such as discolored corneal tattoos, white pupil due to inoperable cataract with clear cornea, and dense corneal opacities in blind eyes. Elective corneal tattooing seems to be a viable and convenient method to improve cosmesis with minimal complications and high patient satisfaction.

Background

While corneal tattooing has been performed for centuries, it has gained renewed interest due to its simplicity and versatility.[1-3] Initially derived to improve cosmesis in blind eyes with disfiguring corneal opacification, the indications for corneal tattooing have been expanding. It has been used to cosmetically improve leukocoria,[1] reduce glare from iris defects, and reduce light scatter from eccentric semi-translucent corneal scars.[4-6] More recently, it has been used to address visual obscuration in a case of strabismus with intractable diplopia.[7]

For many surgeons, a major deterrent to corneal tattooing is the limited commercial availability of medical-grade dye.[1] The variety of dyes that are currently being used may also contribute to variability in outcomes.[3] A metallic dye such as gold or platinum chloride is generally applied to a de-epithelialized corneal surface.4 This technique is reportedly easier and quicker but fades more rapidly.[6] Another dye, a carbon-based alternative such as India ink, can be applied with repeated stromal puncture, by intrastromal injection, or by topical application to the stromal bed after constructing an anterior stromal flap.[1,6]

In this study, we evaluated the clinical outcome of corneal tattooing for various types of corneal opacities.

Methods

A retrospective chart review was conducted for 62 eyes of 62 patients (38 males and 24 females) who underwent corneal tattooing for various corneal opacities between March 2016 and August 2017 at Myongji Hospital, Hanyang University College of Medicine. All patients were referred for cosmetic improvement. Inclusion criteria included corneal opacity or inoperable lens opacity with clear cornea for longer than 5 years without active inflammation or ongoing ocular disease with the visual acuity of LP (Light Perception) and NLP (Non Light Perception). Patients who had visual acuity better than LP were excluded. Age, gender, cause of corneal opacity and other ocular findings were evaluated. This study was initiated after being approved by the institutional review board of Myongji Hospital, Hanyang University College of Medicine. All patients provided written informed consent. This study adhered to the tenets of the Declaration of Helsinki.

SURGICAL PROCEDURE

All surgeries were performed by a single surgeon (JWK). After obtaining informed consent, patients were prepped and draped in standard fashion for ophthalmic surgery(Fig.1A). Under topical anesthesia with 0.5% proparacaine hydrochloride (Alcaine, Alcon Canada Inc, Mississauga, Ont.), a 30-gauge needle on a 1cc syringe filled with black tissue marking dye (Davidson Marking System, Bradley Products Inc, Minneapolis, MN, USA) which had been sterilized in an autoclave at 134°C for 6 min before surgery was used to repeatedly puncture and inject the corneal stroma in the area of corneal opacification. The main ingredient of the dye we used for this study are carbon oxide(CO, CO2) and organic compounds. The needle was held bevel up and punctures were made at an acute entry angle to the corneal surface and extended to approximately 30% depth into the corneal stroma(Fig.1B, 1C).[8-13] Great care was taken to avoid perforating the cornea referencing corneal thickness measured by preoperative anterior segment optical coherence tomography (RS-3000 Advance, Nidek Co LTD, Japan) and ultrasoound pachymetry. Vigorous irrigation with balanced salt solution was administered throughout the procedure(Fig 1D). At the end of each procedure a therapeutic contact lens (1-day ACUVUE 20.50 Diopter, 14.2 mm in diameter, and 8.5 mm in base curve; Johnson & Johnson, Jacksonville, FL) was applied over the cornea. Topical levofloxacin (Cravit, Santen Pharmaceutical Co, Osaka, Japan) and prednisolone acetate (Pred Forte, Allergan Inc, Irvine, CA.) were prescribed to prevent postoperative infection and inflammation 4 times a day for 3 weeks. Therapeutic contact lenses were removed after epithelization of the corneas. The patients were followed-up at 1 day, 1 week, 2 weeks, and at 1, 3, 6, 12, 18, and 24 months after surgery. Ophthalmic examinations, including anterior segment photography and slit lamp examinations were performed. Cosmetic outcomes score were assessed using a subjective visual analogue scale from 0 - 4; 0 being very unsatisfied and 4 being very satisfied.

Results

The average age of the patients in this study was 48.47±15.30 (range, 12-74) years old. The mean follow-up period was 23.19 ±2.34 (range, 19-27) months. The most common causes of corneal opacity were ocular trauma (33 eyes, 53.2%), prior retinal surgery (9 eyes, 14.5%), congenital etiologies (8 eyes, 12.9%) and measles (5 eyes, 8.0%) (Table 1). Corneal opacity caused by prior retinal surgery included

corneal decompensation secondary to repeated retinal detachment operations, and band keratopathy secondary to intraocular silicone oil for retinal attachment. The most common associated ocular findings were strabismus (23 eyes, 37.0%), phthisis bulbi (17 eyes, 27.4%) and band keratopathy (13 eyes, 20.9%) (Table 2). Postoperative complications observed were conjunctival injection (37eyes, 59.6%), subconjunctival hemorrhage (15eyes, 24.1%), and delayed epithelial healing (11eyes, 17.7%)(Table 3). All resolved within 3 weeks with prompt treatment. Mild depigmentation was noted in 7 eyes (11.3%) at postoperative 12 months.

There were no serious complications *e.g.* infection, inflammation, persistent epithelial defect and endophthalmitis. Cosmesis improved in all cases, and most patients were either very satisfied (51patients, 82.3%) or satisfied(11patients, 17.7%). The average cosmetic outcomes score was 3.82± 0.38 (range 3-4) point.

Selected cases:

Case 1

A 25 year old woman was referred for evaluation of an orange-colored cornea from previous tattooing. At three years of age, she suffered trauma to the left eye resulting in corneal opacification. Two years prior to presentation she underwent Ahmed glaucoma valve implantation and corneal tattooing with a brown dye at another hospital. Over the course of two years, the brown-pigmented tattoo became progressively orange in color and cosmetically problematic. She was unable to wear a contact lens due to ocular surface discomfort. On presentation, she denied eye pain. Her visual acuities were 20/20 and no light perception in the right and left eye, respectively. The intraocular pressure was 19 and 22 mm Hg in the right and left eye, respectively. Slit-lamp examination revealed bright orange dye throughout the corneal stroma. Additionally, orange dye had migrated into the adjacent conjunctiva at the 9 to 2 o'clock hours. There was no view to the anterior chamber (Fig.2A, 2C). The patient underwent the procedure described above, but also required excision of the stained conjunctiva. At postoperative week one, the excised conjunctiva re-epithelialized and the therapeutic contact lens was removed. Throughout a 24 month follow-up period, there was no evidence of ocular inflammation and the cosmetic results were stable (Fig. 2B, 2D).

Case 2

A 38-year-old male with congenital microphthalmos presented with a white cataract in his left eye. He denied any previous ocular surgery. On examination, his best corrected visual acuity was 20/20 (-5.50Dsph) in the right eye and NLP in the left eye. Slit lamp examination of the left eye revealed a white pupil with clear cornea and microphthalmia (Fig. 3A,3C). After providing informed consent, he underwent tattooing of the central cornea to mask his leukocoria. The diameter of tattooing was made larger than that of the pupil upon dilation. He received postoperative care as described above. He was followed up for 18months and was satisfied with the result (Fig.3B,3D).

Case 3

A 49-year old male was referred for evaluation of a left corneal opacity. He suffered blunt ocular trauma 10 years prior and developed corneal opacity 3 years later. 2 years subsequently, he underwent strabismus surgery. His best corrected visual acuity(BCVA) was 20/20 in the right eye and LP in the left eye. Intraocular pressures were 17 and 6, respectively. His left eye was phthisical with total corneal opacification and thick band keratopathy (Fig.4A,4C). He agreed to calcium removal and corneal tattooing surgery. With topical anesthesia, the calcium and minimal underlying scarred stroma was removed with Vannas scissors and corneal tattooing was performed as described.

Aforementioned postoperative care was given until the last at follow up of 12 months. Cosmesis improved without complications and he was satisfied (Fig.4B,4D).

Discussion

This study demonstrates successful application of corneal tattooing in various of clinical scenarios such as discolored corneal tattoos, white pupil due to inoperable cataract, and total corneal opacity with thick calcium deposits. In all patients, our cosmetic results were durable without serious complications for at least a 19-month follow-up period.

While corneal tattooing has had a favorable safety profile in many prior studies,5 complications from corneal tattooing do exist. For this reason, corneal tattooing is generally reserved for patients who have failed non-invasive alternatives such as colored contact lenses or scleral shells.

Among the potential complications of corneal tattooing, corneal perforation is a particularly important consideration in scarred, irregular and/or thin corneas.[8] Exacerbated corneal scarring and thickening have previously been implicated as sequelae of the corneal tattooing process.[3] One study evaluating the histologic outcomes in keratopigmentation found that the pigment granules of non-metallic dyes are found exclusively within keratocytes.[6] However, toxicity to stromal keratocytes, endothelial cells, or adjacent tissues is not well understood and requires further investigation.

The main ingredient of the dye we used for this study (black dye, Davidson Marking System, Bradley Products Inc, Minneapolis, MN, USA) are carbon oxide(CO, CO2) and organic compounds which is used for many published studies without serious toxicity.[4, 8-11]

Fading or discoloration of the impregnated pigment is another concern in keratopigmentation. However, according to a study by Kim et al, 5-year results in corneal tattooing are promising with only 12% of patients experiencing color fading or increased corneal opacity.[9] This suggests that keratopigmentation can indeed have good durability. Our current study corroborates these findings. For the cases where minimal depigmentation was noted, it may have been the case that the scars in these cases were so dense that they prevented deep penetration of the dye and caused leakage over time. There are many

techniques for corneal tattooing such as anterior stromal puncture[14], stromal impregnation (used here), and pigment corneal stromal insertion through lamellar intrastromal channels.[15]

Intrastromal impregnation has been widely used and well described.[4, 8-11] This method has the advantages of controlling injection depth and seeing the exact result during surgery. When the surgeon is able to visualize the needle tip and bevel, it is not difficult to avoid perforation of the cornea. Femtosecond laser can also be applied to corneal tattooing.[1,15] This method has the advantage of customized and precise incision placement thus theoretically reducing the risk of perforation,[15] but also carries the disadvantage of not being applicable to all depths of corneal opacities such as in cases of shallow anterior stromal opacities. For femtosecond laser procedures, dye is injected into the interface between the flap and stroma, if the opacity is anterior to the flap, the opacity would not be covered by posteriorly injected dye.

In this study, we performed corneal tattooing for eyes with no visual potential, but Alio et al reported keratopigmentation to change the apparent color in sighted eyes.[16] Corneal tattooing for eyes with visual potential should be investigated further for long-term safety and efficacy.

Conclusion

In conclusion, corneal tattooing is technically relatively simple and generally safe, not only for the cosmetic treatment of blind disfigured eyes, but also for improvement of patients' quality of life for an expanding range of clinical scenarios.

Declarations

Ethics approval and consent to participate

The study protocol was in accordance with the Declaration of Helsinki and was approved by the institutional review board of Myongji Hospital, Hanyang University College of Medicine, Seoul, Korea (MIRB 2018-04-003-001). Additionally, written informed consent was obtained from all participants.

Consent for publication

Patients provided written informed consent after being given a detailed explanation of the study. We confirmed that patients agreed to data publication in a journal

Availability of data and materials

All data are available upon request.

Competing Interests

The authors have no other proprietary or commercial interest in any materials discussed in this article. No conflicting relationship exists for any author

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Authors' Contributions

JJ made design for the study, JDF carried out statistical analysis, JKL revised the manuscript, RSC participated in its design and coordination and helped to draft the manuscript, JWK participated in its design and coordination and helped to draft the manuscript. All authors read and approved the final manuscript.

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Not Applicable

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Tables

TABLE 1. Etiology of Corneal Opacity

Etiology	Eyes(%)
Trauma	33(53.2)
Retinal disease	9(14.5)
RD	7(11.3)
PHPV	2(3.2)
Congenital	8(12.9)
Measles	5(8.0)
Unknown	7(11.3)

TABLE 2. Associated Ocular Findings

Associated Ocular Findings	Eyes(%)
Strabismus	23(37.0)
Phthisis bulbi	17(27.41)
Band keratopathy	13(20.9)

TABLE 3. Postoperative Complications

Postoperative Complications	Eyes(%)
Conjunctival Injection	37(59.6)
Subconjunctival Hemorrhage	15(24.1)
Delayed epithelial healing	11(17.7)
Unnoticeable depigmentation	7(11.3)

Figures

Figure 1

Corneal tattooing in a 38-year-old man. (A) :Before tattooing, Y-sphaped corneal opacity and white cataract were seen. (B,C): A 30-gauge needle on a 1cc syringe filled with black tissue marking dye was used to repeatedly puncture and inject the corneal stroma in the area of corneal opacification. (D):The tattooing procedure is completed with vigorous irrigation with BSS solution.

Figure 2

A 25-year-old woman with an orange-colored cornea caused by a previous corneal tattooing with a brown dye. (A,C): Prior to corneal re-tattooing. (B, D): 12 months after corneal re-tattooing. Orange colored cornea turned to more natural color.

Figure 3

Anterior segment photographs before and after surgery. (A,C):Before surgery. A white pupil due to cataract and microphthalmia was observed in the left eye. (B,D):13 months after central corneal tattooing. Pigment masks the white pupil well.

Figure 4

Anterior segment photographs before and after surgery. (A,C):Before surgery. Total corneal opacity with thick band keratopathy is shown. (B,D) :12 months after total corneal tattooing with calcium removal. There was no recurrence of band keratopathy.