A novel indigenous technique for corneal tattooing using self-prepared do-it-yourself carbon soot pigment

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Purpose: To evaluate the cosmetic efficacy and safety of an indigenous novel corneal tattooing technique using a self-prepared candle soot pigment. Methods: This pilot observational study involved 22 eyes of patients at a Bengaluru-based ophthalmology setting. The study considered only eyes with nil or low visual potential. Eyes with active ocular inflammation, nasolacrimal obstruction, severe hypotony, and shrunken globe due to phthisis bulbi were excluded. The surgery was carried out under aseptic conditions using a self-prepared carbon soot pigment. Different methods such as lamellar, surface needle micropuncture, machine-assisted surface tattooing, or a combination were used for pigment application. Results: Ten eyes underwent combined lamellar and surface tattooing; lamellar tattooing was performed for 11 eyes, and surface tattooing for one eye. Nineteen patients underwent limbus-to-limbus corneal tattooing and three patients had undergone focal tattooing to cover nasal pterygium scar, inferior iridectomy, and leukocoria due to calcific cataract. Nearly 91% were subjectively satisfied with the tattooing technique and 82% had excellent cosmetic coverage along with subjective satisfaction. None of the subjects required a repeat surgery or augmentation of tattooing. There was no reported case of corneal inflammation, epithelial erosions, infiltrations, infections, nonhealing areas, stromal melting, or any other complications. Conclusion: This novel procedure, involving self-prepared carbon soot pigment tattooing, provides excellent cosmetic results and high patient satisfaction. It is relatively safe, easy to perform, and the conventional steps of tattooing such as pigment procurement, storage, and sterilization can be avoided, as the carbon pigment is freshly prepared under aseptic conditions.

Key words: Carbon, cornea, keratopigmentation, soot, tattooing

Cosmetic surgeries have become an integral part of ophthalmology in an attempt to improve the patient’s facial appearance, increase self-esteem and confidence by reducing social stigma. Corneal tattooing is a well-established surgery to mask corneal discolorations and white reflexes in the eyes with low or nil visual potential. It is also indicated to reduce symptomatic glare and visual disturbances caused by various pupillary and iris defects. The common indications for performing tattooing include corneal scars, adherent leucomas, iris defects, strabismic diplopia, and Urrets–Zavalia syndrome.[1]

The chemical tattooing technique was first introduced by Galen (131-210 AD) who used reduced copper sulfate to cosmetically correct corneal opacity.[2] The advent of newer generation use of pigments and novel surgical techniques including the surgical instruments for creating sclerocorneal tunnels, increasing popularity of corneal lamellar surgeries, tattooing machines, and femtosecond-laser-assisted tattooing surgery have contributed in achieving increased safety, longevity, and stability in terms of cosmetic outcomes.[3] Keratopigmentation surgery also helps to avoid problems associated with poor tolerance to prosthetic-colored contact lenses and more invasive surgical procedures such as penetrating keratoplasty, enucleation, and evisceration.[4]

Literature studies have reported the use of chemical and coloring methods for keratopigmentation. Chemicals used were gold chloride, platinum chloride, and silver nitrate, reduced in situ by hydrazine hydrate. This produced brown to black precipitates. The coloring method involved direct impregnation of coloring pigment such as India ink, organic colors, ferric oxide, Chinese ink, etc.[5]

The present study is intended to evaluate the cosmetic efficacy and safety of a novel surgical technique using a self-prepared candle soot pigment for corneal tattooing.

Methods

The pilot observational study considered the eyes of patients who were seeking treatment at the outpatient department (OPD) of a Bengaluru-based ophthalmology setting between 2015 and 2019. A thorough history was obtained and a comprehensive outpatient assessment of both eyes was performed. The patients were informed about the surgical procedure, possible complications, and alternatives. Informed consent was obtained before surgery. Only eyes with nil or low visual potential were considered for total corneal tattooing. Eyes with active ocular inflammation, nasolacrimal obstruction, severe hypotony, and shrunken globe due to phthisis bulbi were excluded. Prephthisical eyes with acceptable intraocular pressure were included after a detailed explanation about the possibility of worsening/progression of the phthisical process. Preoperative assessment included visual acuity (with emphasis on perception of light and projection of rays), slit-lamp biomicroscopy, intraocular pressure assessment,

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dilated retinal examination of both eyes (where ever possible), regurgitation on pressure over the lacrimal sac/syringeing, face and anterior segment photography, and B scan. The iris color of the other eye was noted. The systemic investigations included hemoglobin, total and differential blood counts, erythrocyte sedimentation rate (ESR), postprandial blood sugar (PPBS), and electrocardiogram (ECG). A fitness certificate for ocular surgery under regional anesthesia was obtained from a physician for all the patients. A psychological evaluation of the patient and family was performed.

**Surgical procedure**

The surgery was carried out in the operating theatre under peribulbar, retrobulbar, or topical anesthesia. Standard preoperative preparations for an eye surgery were followed, including 5% povidone-iodine painting of skin and adnexa, cul-de-sac wash with 0.5% diluted povidone-iodine solution, and standard draping to isolate the lids and lashes.

Carbon soot pigment was prepared in the operation theatre (OT) under aseptic conditions [Fig. 1]. A sterile stainless-steel gallipot, sterile stainless-steel artery forceps, and a wax candle were used. The soot was collected by keeping the gallipot inverted over the candle flame, holding it with sterile artery forceps. A large area of the gallipot was exposed and a thick layer of carbon soot was obtained under aseptic precautions.

Ethylene diamine tetra-acetic acid (EDTA) chelation and superficial keratectomy were performed for patients with band keratopathy. After surface anesthesia with few drops of proparacaine, sterilized EDTA crystals were placed on the affected areas of the cornea for dissolving plaques. The total exposure to EDTA ranged from 1 to 4 min, depending on the amount of calcium deposition. Superficial keratectomy was performed by scraping the involved corneal surface with an obliquely held 15 number disposable surgical blade or a crescent knife to remove the calcium deposits and smoothen the cornea.

Different methods of pigment application were utilized, depending on the pathology, extent, density, and depth of the corneal scar. Lamellar, surface needle micropuncture, machine-assisted surface tattooing, or a combination of them were chosen.

To perform lamellar tattooing, a scleral, limbal or corneal lamellar incision of 3 to 4 mm was made and a lamellar pocket was dissected to cover the entire corneal scar area using a crescent blade or lamellar dissector. If the entire cornea was scarred, two entries were needed from opposite meridians. Minimal cautery was performed to control bleeding if any. The general depth of the corneal pocket was midstromal, but if the scar was mid and superficial stromal, a 1/4 to 1/3 depth dissection was performed. The pocket was washed with balanced salt solution (BSS) to clear blood and debris. The soot was scraped from the gallipot using a blunt crescent and was stuffed into the lamellar pocket till the entire area was well covered [Fig. 2]. Repeated and copious washing of the surface was done to confirm that interlamellar tattooing was adequate.

The lamellar tattooing was augmented with surface tattooing in patients with superficial scarring and dense band keratopathy. The surface epithelium was removed by rubbing it with a cotton bud dipped in 20% ethyl alcohol. Few flakes of soot were applied to the residual opacity. Multiple punctures were performed in an oblique direction with a 30 G needle to carry the pigment by the needle into the corneal stroma. The orientation of the needle was around 45° and the pricks were 1/4 to 1/3 of the thickness of the cornea. In two patients, micropunctures were performed using a tattooing machine (patients 18, 22). Usage of the tattooing machine gave quicker, denser, and darker tattooing. The corneal surface was washed several times in between to remove the excess soot and improve the visibility of the residual white areas. This process was continued till good cosmetic coverage was obtained.

The tunnel was sutured in required cases but was not needed in majority of the eyes. Fibrin glue was used to close the conjunctival opening when needed. Bandage contact lenses were applied in few cases and the eyes were covered with pad and bandage. The bandage contact lens was removed anytime

**Figure 1:** Steps involved in the preparation of carbon soot

**Figure 2:** Surgical steps involved in corneal tattooing of patient no. 21
| Patient | Sex | Age | Primary Diagnosis                                                                 | Associated findings * | Corneal tattooing surgery details | Additional surgery                  | Follow-up                   | Coloring effect on last visit |
|---------|-----|-----|------------------------------------------------------------------------------------|------------------------|----------------------------------|-------------------------------------|----------------------------|-----------------------------|
| 1       | M   | 67  | Leucomatous corneal scar, bullous keratopathy                                      | A, G, E, P              | Lamellar                         | -                                   | 8 years 7 months            | +++                         |
| 2       | M   | 28  | Corneal opacity, band keratopathy                                                  | T, C, P                | Lamellar+surface                 | EDTA chelation and superficial keratectomy | 5 years 9 months          | +++                         |
| 3       | M   | 46  | Inferior sector iridectomy with diplopia, inferior corneal scar                   | T, C, G,               | Lamellar tattooing, Inferior cornea only | -                                   | 6 years 4 months           | +++                         |
| 4       | F   | 42  | Adherent leucoma                                                                      | T                      | Lamellar+surface                 | -                                   | 1 month                    | +++                         |
| 5       | M   | 46  | Corneal opacity, band keratopathy                                                  | T, R, P                | Lamellar+surface                 | EDTA chelation and superficial keratectomy | 1 year 11 months         | +                           |
| 6       | F   | 14  | Corneal opacity, band keratopathy                                                  | E                      | Lamellar                         | EDTA chelation and superficial keratectomy | 6 years                   | +++                         |
| 7       | F   | 18  | Leucomatous corneal opacity, band keratopathy                                      | R                      | Lamellar+surface                 | EDTA chelation and superficial keratectomy | 1 month                   | +++                         |
| 8       | M   | 78  | Macular corneal opacity                                                              | G, E                   | Lamellar                         | -                                   | 5 years                    | +++                         |
| 9       | F   | 32  | Corneal opacity, inferior corneal decompensation                                   | T                      | Lamellar                         | -                                   | 2 months                   | +++                         |
| 10      | F   | 51  | Leucomatous corneal opacity                                                        | T, P                   | Lamellar                         | -                                   | 3 years 2 months           | +++                         |
| 11      | M   | 33  | Corneal opacity                                                                      | T, A, E                | Lamellar                         | Squint surgery                      | 1 year 8 months           | +                           |
| 12      | F   | 26  | Leucomatous corneal opacity, band keratopathy                                      | P                      | Lamellar+surface                 | EDTA chelation and superficial keratectomy | 1 month                   | +++                         |
| 13      | M   | 37  | Leucomatous corneal opacity                                                        | T                      | Lamellar                         | -                                   | 2 months                   | ++                          |
| 14      | M   | 17  | Adherent leucoma                                                                      | T                      | Lamellar+surface                 | EDTA chelation and superficial keratectomy | 1 year                    | +++                         |
| 15      | F   | 59  | Failed corneal graft, adherent leucoma                                               | -                      | Lamellar                         | -                                   | 6 months                   | +++                         |
| 16      | M   | 18  | Adherent leucoma                                                                      | P                      | Lamellar                         | -                                   | 1 month                    | +++                         |
| 17      | M   | 40  | Vascularized corneal opacity, bullous keratopathy, ciliary staphyloma              | T, E                   | Lamellar+surface                 | Squint surgery                      | 1 year                     | +                           |
| 18      | M   | 26  | Corneal opacity, exotropia, ptosis hypotropia, band keratopathy                   | G, E                   | Lamellar+surface                 | EDTA chelation and superficial keratectomy | 5 months                  | +++                         |
| 19      | F   | 60  | Nasal corneal opacity status post pterygium excision                               | -                      | Surface tattooing, nasal corneal only | Pterygium excision                 | 1 year                     | +++                         |
| 20      | M   | 60  | Corneal opacity                                                                      | A, R, P                | Lamellar                         | EDTA chelation and superficial keratectomy | 4 months                  | +++                         |
| 21      | M   | 30  | Corneal opacity, band keratopathy, silicon oil in AC                                | E                      | Lamellar+Surface                 | EDTA chelation and superficial keratectomy | 7 months                  | +++                         |
| 22      | F   | 19  | Callicic white cataract                                                             | R, C, N                | Lamellar+surface, Central corneal only | -                                   | 2 months                   | +++                         |

+++ = Good coverage and good subjective satisfaction, ++Slight fading but good subjective satisfaction, + slight fade with patient slightly dissatisfied.

*G=Glaucoma, E=Exotropia, P=Prephthysical, A=Aphakia, C=Cataract, S=Staphyloma, R=Retinal detachment, N=Nystagmus, T=Trauma related
Results

The study involved 22 eyes of 22 patients with a mean age of 38.5 years (range: 17–78 years) and a male-to-female ratio of 1.0.7. Twelve surgeries were performed by surgeon 1 and ten surgeries by surgeon 2. Fourteen eyes needed corneal tattooing and eight eyes needed tattooing combined with EDTA chelation and superficial keratectomy. Ten eyes underwent combined lamellar and surface tattooing, lamellar tattooing alone and surface tattooing alone were performed in 11 eyes and 1 eye respectively. Squint correction for exotropia was performed for three patients in the same sitting (patients 11, 17, 18). Nineteen patients underwent limbus-to-limbus corneal tattooing. One patient underwent tattooing to cover the pterygium scar (patient 19) and another patient underwent sectoral tattooing to cover an inferior iridectomy (patient 3). Central 6 mm tattooing, to cover the leukocoria caused by calcific cataracts, was also carried out in one patient (patient 22). No complications were noted during the surgery and no changes were needed in the scheduled planning of the surgery. There were no corneal perforations noted in any of the surgeries including those requiring lamellar dissection. No other intraoperative complications were noted. None of the patients had a recurrence of band-shaped keratopathy till the last follow-up.

During the postoperative recuperation: irritation, redness, and foreign body sensation were reported by all the patients, which resolved within the first 2 weeks. Corneal reepithelialization was completed within 3 to 10 days. The patient satisfaction rate noted was 90.90% (20 eyes) and satisfaction along with excellent cosmetic coverage was 81.81% (18 subjects). Two patients (patients 5 and 13) felt mild fading of color from the time of surgery to the last follow-up but were still cosmetically satisfied. Patient 5 had a vascularized scar, which could be the reason for the fading. Though patients 11 and 17 had adequate coverage, they felt that the color was not perfectly matching with the other eye, especially in bright direct light. Patient 17 was advised to wear prosthetic contact lens for better matching with the other eye during social occasions. None of the patients needed a repeat surgery or augmentation of tattooing. There was no corneal inflammation, epithelial erosions, infiltrations, infections, vascularization, nonhealing areas, stromal melting, or any other adverse effect. Clinical data including demographics, primary diagnosis, associated clinical findings, surgical technique, coloring effect till the last follow-up, and patient satisfaction are listed in Table 1. Pre- and postoperative clinical images are provided in Figs. 3-5.
Discussion

Over the decades, there have been several studies proving the cosmetic results and safety of keratopigmentation. Karslıoğlu et al.[6] have evaluated the outcomes including postoperative patient satisfaction, cosmetic results, pigment stabilization, and surgical complications in 16 eyes following intrastromal and superficial keratopigmentation using commercial tattooing ink or micronized mineral particle. The study concluded that the procedure is very safe and simple with no requirement and simple method of expensive materials. Mild-to-moderate pigment loss was seen in 12.5% of patients at end of 12 months. Alio et al.[8] have reported that keratopigmentation using micronized mineral pigment is an effective surgical procedure to manage visual disabilities associated with iris defects. Alio et al.[9] have also advocated keratopigmentation as a promising alternative for extensive and mutilating reconstructive procedures. The researchers evaluated 40 eyes that had undergone corneal staining with mineral micronized pigments and the results were promising with good patient outcomes and high patient satisfaction. Alsmman et al.[10] have performed corneal tattooing using Rotring painting ink for treating corneal disfiguring opacities of 53 blind eyes. The 12-month follow-up reported a satisfying cosmetic appearance in 96% of the patients with no major complications such as corneal ulcers, corneal erosions, or corneal melting. The 5-year results of corneal tattooing in 147 patients published by Kim et al.[9,14] have reported fading of color, epithelial growth, and reopacification, or increased opacity in 12% of the eyes between 2–4 years of the surgery. The study noted persistence of good cosmetic outcomes following the tattooing of disfigured eyes, even after 5 years of surgery.

A more recent study published by Kaur et al.[11] has reported long-term, cosmetically satisfying outcomes following the use of India ink for coloring, based on the lamellar pocket procedure. There is substantial evidence to validate the improved cosmetic outcomes in the “lamellar pocket technique,” with enhanced pigment deposition due to staining of both surfaces of the stromal pocket. The present study has used the lamellar pocket method for all except one patient, with extremely satisfying cosmetic results.

The dye- or pigment-related complications reported in the literature include inflammatory reactions, unacceptable granulomas, and discoloration ranging from mild fading to total loss of color.[12,13] The inflammatory or granulomatous side effects were described in the chemical methods with the use of metallic dyes and not with the coloring method. Fading is the most common concern.

The percentage of satisfaction and results noted in the current study are comparable to that of previous findings.[9,14] None of the patients had any complications during the operative and perioperative periods. Eighteen patients (81.81%) had excellent coloring and patient satisfaction till their last follow-up. Two patients showed mild fading but had good subjective satisfaction. Two patients felt the need for additional modalities for better cosmesis. The lack of local or systemic toxicity substantiates the potential use of freshly prepared clean soot, with no preservatives, as a pigment to achieve a black shade that matches the Indian iris color extremely well.

The past few decades have witnessed the use of various coloring agents for corneal tattooing. The chemical method with gold chloride, platinum chloride, and silver nitrate, along with reducing agent hydrazine hydrate, produces a brown to black precipitate. The coloring method involves direct impregnation of corneal pigment such as India ink, organic colors, Chinese ink, etc., into the corneal tissue.[13] The majority of the presently used tattooing dyes/pigments/chemicals are not meant for ophthalmic use and they need to be sterilized before use.[14,15,16] In the current method, the carbon pigment was prepared freshly under aseptic precautions for direct use. None of the patients in the study developed any corneal infections.

The major limitation of the current study is not able to follow-up all the subjects for a long-term due to their inconsistent visits to the hospital. Another limitation is a relatively small number of observed patients. The use of self-prepared carbon soot in the current study has the advantage of being inert, nontoxic, inexpensive, and the ability to be prepared freshly in an ophthalmologic surgical setting using only a candle and gallipot.

Conclusion

This novel procedure of self-prepared carbon soot pigment is relatively safe, easy to perform, and assists in achieving excellent cosmetic results and high patient satisfaction during corneal tattooing. Since the carbon pigment is freshly prepared following aseptic precautions, conventional steps of tattooing such as pigment procurement, storage, and sterilization can be avoided. However, further studies involving a larger study population are warranted to corroborate the long-term safety of the procedure.

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Conflicts of interest
There are no conflicts of interest.

References

1. Ferrari F, van Haselen R. The safety and effectiveness of a novel annular keratopigmentation method: A case report. Case Rep Ophthalmol 2018;9:35-42.
2. Rodriguez AE, Amesty MA, Bahrawy ME, Rey S. Superficial automated keratopigmentation for iris and pupil simulation using micronized mineral pigments and a new puncturing device: Experimental study. Cornea 2017;36:7.
3. Kim JH, Lee D, Hahn TW, Choi SK. New surgical strategy for corneal tattooing using a femtosecond laser. Cornea 2009;28:80-4.
4. Alió J, Rodrigo A, El Bahrawy M, Angelov A, Zein G. Keratopigmentation to change the apparent color of the human eye: A Novel indication for corneal tattooing. Cornea 2016;35:431-7.
5. Irfan S, Rashid F, Shahzad I. To assess the efficacy of chemical corneal tattooing for unsightly corneal scars. Pak J Ophthalmol 2014;30:151-5.
6. Karslıoğlu M. Keratopigmentation: Is it a miracle or an adventure? Beyoğlu Eye J 2020;5:32-7.
7. Alio JL, Rodriguez AE, Tofahaa BT. Keratopigmentation (corneal tattooing) for the management of visual disabilities of the eye related to iris defects. Br J Ophthalmol 2011;95:1397-401.
8. Alio JL, Sirerol B, Walewska-Szafran A, Miranda M. Corneal tattooing (keratopigmentation) with new mineral micronised pigments to restore cosmetic appearance in severely impaired eyes. Br J Ophthalmol 2010;94:245-9.
9. Alsmman AH, Mostafa EM, Mounir A, Farouk MM, Elghobaier MG, Radwan G. Outcomes of corneal tattooing by rotting painting ink in disfiguring corneal opacities. J Ophthalmol 2018;2018:5971290.
10. Kim C, Kim K, Han YK, Wee W, Lee J, Kwon J-W. Five-year results of corneal tattooing for cosmetic repair in disfigured eyes. Cornea 2011;30:1135-9.
11. Kaur M, Singh S, Singh M. Corneal tattooing with India ink in a young male. Delhi J Ophthalmol 2019;30:67.
12. Zwerling CS. Corneal micropigmentation. Ann Rev Resear 2018;1:138-41.
13. Sharma A, Gupta P, Dogra MR, Hidayat AA, Gupta A. Granulomatous keratitis following corneal tattooing. Indian J Ophthalmol 2003;51:265-7.
14. Doganay D, Doganay S, Cankaya C. Corneal tattooing for esthetic purposes in patients with corneal opacities. Indian J Ophthalmol 2020;68:1033-6.
15. Pitz S, Jahn R, Frisch L, Duus A, Pfeiffer N. Corneal tattooing: An alternative treatment for disfiguring corneal scars. Br J Ophthalmol 2002;86:397-9.
16. Alsmman A, Gamal N. Intrastromal injection of China painting ink in corneas of male rabbits: Clinical and histological study. J Ophthalmol 2016;2016:1-6.