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Keratopigmentation as cosmetic treatment for leukocoria related to unilateral cataract in a blind eye: A case series

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Abstract
Purpose: To report four cases of unilateral blindness and total white cataract without indication for facectomy, evaluating the different keratopigmentation techniques for each case.
Methods: This was a retrospective comparative study of a case series of four patients with unilateral blindness, clear cornea, and white total cataract who underwent keratopigmentation using different techniques according to the most appropriate clinical indication for each case.
Results: The keratopigmentation procedure proved to be safe without intraoperative and postoperative complications. Regarding subjective evaluation, all patients were very satisfied with the final aesthetic result, resulting in subjective improvements in personal well-being.
Conclusions: Keratopigmentation achieves satisfactory and long-lasting aesthetic results. It is not very painful and can be performed using different techniques that must be customized according to each case, increasingly reinforcing this surgery as a safe therapeutic alternative that can promote great social impact on patients' lives.

Keywords: Keratopigmentation, tattoing, cornea, corneal opacity, cataract

Introduction
Keratopigmentation (KTP), or stromal cornea tattooing, is a method that has been used for centuries to cosmetically treat corneal lesions [1]. The first record of KTP described it as a technique used for the aesthetic treatment of patients with corneal leukomas [2]. Its purpose can be functional or cosmetic, treating both debilitating visual symptoms, such as light scattering, photophobia, or disabling diplopia, while improving the aesthetic appearance of patients without visual prognosis [2, 3]. Among the various indications, the most common is corneal opacity in blind eyes, the main causes of which are ocular trauma (50.6%), retinal pathology (15.5%), measles (9.5%), and congenital causes (5.5%) [3, 4].
The procedure consists of corneal stroma implantation of micropigments of different colors to change the color of the cornea [1]. Currently, there are four previously described techniques that are divided into superficial and stromal categories. The superficial types are manual (manual superficial KTP) and automated using a dermograph (superficial automated KTP). The intrastromal techniques are manual, in which a stromal dissection tunnel is created manually for pigment implantation (manual intrastromal KTP) and a technique using femtosecond laser-assisted KTP [3, 5, 6]. Major improvements have been made recently, both in the techniques and in the quality of the pigments used, improving the safety and stability of these substances in the cornea as well as improving the patients' aesthetic results [2, 3, 7].
The objective of this study was to report the cases of four patients with unilateral blindness and total white cataract who were not indicated for facectomy and to evaluate the different KTP techniques indicated for each case.

Materials and Methods
This was a comparative analysis of a case series of four patients with unilateral blindness, transparent cornea, and total white cataract who underwent KTP using different techniques between 2021 and 2022. The surgeries were performed by the same surgeon, and the surgical technique used was decided based on the most appropriate clinical indication for each case.

Different colors of sterile single-dose Electric Ink® pigments for tattooing (composed of deionized water, non-ionic surfactant, vegetable glycerin, propylene glycol, and pigments) were used to achieve appropriate and symmetrical shades to the contralateral eyes of each patient. None of the eyes had previously undergone any cosmetic treatment. No patient underwent corneal transplantation or was indicated for cataract surgery, and all patients had some degree of cosmetic contact lens intolerance.

Results

Four female patients aged between 22 and 69 years underwent KTP to improve their quality of life and aesthetic appearance.

Case 1: A 28-year-old woman had a history of retinal detachment in the left eye for 13 years, with a subsequent onset of unilateral cataract. Her chief complaints were related to aesthetic issues, including depression, due to low self-esteem. She denied feeling pain and wore cosmetic contact lenses but reported intolerance to them. Visual acuity with correction was 1.0 in the right eye and no light perception in the left eye. Biomicroscopy of the right eye showed no alterations, while the left eye had bulbar conjunctival hyperemia of 1+/4+, a clear cornea that did not stain with fluorescein, normal iris, or white cataract.
In this case, the manual intrastromal KTP technique was only used in the central region to simulate the pupil. The area of interest was delineated using a dermatographic pen and subsequently a 3-mm arched incision about 200 µm deep was performed at 10 o'clock, followed by a circular central pouch dissection with 4-mm diameter and black pigment implantation [3, 8, 9]. (Figure 1)

Case 2: A 22-year-old woman with a history of choroid hemangioma in the right eye, discovered at 6 years of age, followed by loss of visual acuity, had a subsequent onset of white cataract 5 years prior to presentation. She reported dissatisfaction with the aesthetic aspect and experienced shame while leaving her home without cosmetic contact lenses. She denied experiencing any eye pain. Although she had mild intolerance to cosmetic contact lenses, the patient wore them anyway. Visual acuity with correction: no light perception in the right eye and 1.0 in the left eye. Biomicroscopy of the right eye showed bulbar conjunctival hyperemia of 1+/4+, clear cornea that did not stain with fluorescein, hyperchromic iris with areas of atrophy, posterior synechiae, and white cataract. Biomicroscopy of the left eye revealed no significant changes.
In case 2, the manual intrastromal KTP technique was used on the entire cornea, in which superficial lamellar dissection of the cornea was performed with direct intrastromal application of pigments. The central corneal area that simulates the pupil was created as described in case 1, and four radial incisions were made to the limbus to dissect the stromal tunnels where the brown pigment was injected [3, 8]. (Figure 2).

Case 3: A 33-year-old woman with a history of retinal detachment after perforating ocular trauma in the left eye 7 years prior and subsequent onset of unilateral cataract reported dissatisfaction with the appearance of the left eye, denied feeling pain, and intolerance to cosmetic contact lenses. Visual acuity with correction was 1.0 in the right eye and no light perception in the left eye. Biomicroscopy of the right eye showed no alterations, and that of the left eye showed 1+/4+ bulbar conjunctival hyperemia, cornea with superficial linear scar that did not stain with fluorescein, inferior corectopia, normal iris, and white cataract.
In this case, a combination of the two techniques was used. First, a central circular intraestromal manual KTP was created to make the pupil black, and subsequently, a half-moon shape tunnel was created to cover dystopian leukocoria with brown color. However, as the patient had a superficial linear scar that stood out above the lamellar pigmentation, superficial manual KTP was later performed, in which the end of a sterile 25-G needle was used to perform stromal punctures with the chosen pigment, in an attempt to cover the scar and improve the final aesthetic result of the surgery [3, 8]. (Figure 3).

Case 4: A 69-year-old woman with a history of retinal detachment in the left eye for 8 years experienced subsequent onset of unilateral cataract. The patient reported an alteration of the color of the left eye (darkening of the iris) associated with a central white spot. The patient denied experiencing pain and did not tolerate cosmetic contact lenses. Best-corrected visual acuity was 0.8 in the right eye and there was no light perception in the left eye. Biomicroscopy of the right eye showed no significant changes, whereas bulbar conjunctival hyperemia of 1+/4+ was present in the left eye, in addition to engorged conjunctival vessels, discrete central diffuse opacities, superficial neovessels, corneal irregularity that did not stain with fluorescein, hyperchromic iris, discrete corectopia and white cataract.
In this case, superficial automated KTP was performed using an electronic device (Ultra Pen Electric Ink® dermograph) that creates superficial micropunctures in the stroma in an automated fashion, and cartridges with needles of one and three tips were used [2, 8, 9]. The colors were added according to the appearance of the contralateral eye. (Figure 4)
Most opacities resulted from retinal detachment (3/4; 75%) and retinal pathologies (1/4; 25%). Based on the results of the subjective evaluation, all patients were highly satisfied with the results obtained. Regarding the intensity of discomfort in the postoperative period, three patients (75%) reported little discomfort, and the patient in case 4 (25%) reported moderate discomfort. All patients reported significant improvement in social and personal well-being and said that they would repeat the procedure. Regarding the surgical aspects, no patient developed any intraoperative complications, and there has been no need for a reapproach so far, with a minimum follow-up of 1 year.

Discussion

The case series described shows the different approaches used to treat patients with unilateral leukocoria associated with blindness and cataracts. None of the patients had a visual prognosis and required only aesthetic correction; therefore, lens extraction and facectomy were not performed as they were contraindicated because of the increased risk of developing phthisis bulbi [10]. The procedures were performed without complications, and the patients were very satisfied with the results.
In blind eyes with clear corneas, intrastromal KTP should be the first choice because it is less aggressive on the ocular surface, the epithelium is preserved, and only a few incisions are made for lamellar dissection of the cornea.

Postoperative recovery is also shorter and minimally painful [5].

In case 1, in which the cornea was transparent, the iris had a normal color and there was no corectopia, and it was possible to perform KTP only in the pupillary region with black pigment, with an excellent result. In case 2, there was diffuse hyperpigmentation of the iris of the affected eye, making it necessary to use the conventional technique of manual intrastromal KTP, staining the pupillary area in black and the iris in brown pigments with the closest possible color to the contralateral eye.

In case 3, the patient's iris had preserved coloration but had inferior corectopia associated with a superficial linear corneal scar; therefore, a combination of two techniques was used, starting with manual intrastromal KTP and staining the pupillary area black. However, due to corectopia, some white cataract was still noticeable. A sectoral inferior dissection was then performed, forming a tunnel in the lower half moon that was filled with a brown pigment similar to the patient's iris color. Therefore, corectopia correction yielded an excellent aesthetic result. As there was a superficial linear scar, the surgery was completed with a superficial manual KTP by performing manual micropunctures to cover the scar above the plane of the lamellar tunnels.

Case 4 presented with superficial corneal opacities, corectopia, and iris hyperpigmentation. The contralateral eye was greenish with shades of green and yellow. This variation in shade cannot be reproduced using the intra-estromal manual KTP technique, as only one color is injected into the stroma. Therefore, to reproduce the natural gradient of the iris of this patient more faithfully, the superficial automated KTP technique with a dermograph was used, which allows the gradual application of different colors, staining the peripupillary region of the iris a more yellowish color, the iris stroma a shade of green, and the iris periphery a shade of darker green, with the final result very close to the contralateral eye.

For the superficial automated technique, full removal of the epithelium is recommended at the beginning of the procedure to ensure that the pigment is introduced into the stroma and not into the soon to be replaced epithelium cells, so that the pigmentation is preserved after healing. However, this makes the postoperative period more painful, and the epithelialization time in these cases is longer [5].

Automated intrastromal KTP using a femtosecond laser is indicated in cases of transparent corneas where pigment implantation in an intrastromal tunnel is planned. However, the high cost and limited availability of this technology are its disadvantages [3, 6, 8].

In our study, the KTP procedure proved to be safe without any intraoperative or postoperative complications. A recent study conducted by Alio *et al*. evaluated the complications in 234 eyes of 204 patients who underwent KTP using techniques similar to those used in the cases described and found that only 12.82% of all cases developed some kind of complication [7]. The most common of which was sensitivity to light (49%), and the least common were limitations of the vision field and changes in magnetic resonance imaging [3, 7]. It should be noted that in this study, KTP was not limited to patients who were blind.

Regarding the subjective evaluation of the patients, four cases were very satisfied with the aesthetic results achieved. The opacities of the cornea or color alterations in the anterior segment generally modify the appearance of the eye, which can directly affect the self-confidence and quality of life of the individual. Patients who are blind in one eye who have white cataracts and transparent or partially opaque corneas can benefit greatly from KTP, bringing subjective improvements in personal well-being and possibly positively affecting other aspects of their private lives.

The presented cases show that KTP yields satisfactory and permanent aesthetic results. This causes minimal discomfort, and different techniques can be customized for each case. Therefore, this surgery is a safe therapeutic alternative not only for patients with leukomatous eyes but also for specific cases of transparent corneas. Further studies should be conducted to evaluate the long-term results of KTP.

Fig 1: A) Preoperative aspect showing central leukocoria due to a white cataract; B) Slit lamp aspect after central manual intrastromal KTP; C) Final aspect.

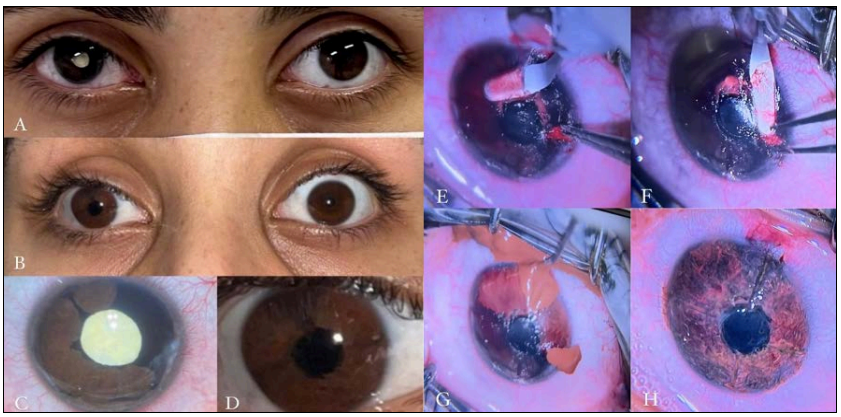

Fig 2: A) Preoperative aspect showing central leukocoria with hyperpigmentation of the iris; B) Bilateral aspect after manual intrastromal keratopigmentation of the right eye; C) Slit lamp aspect before KTP; D) Final slit lamp aspect after KTP; E and F) Cornea superficial lamellar dissection during the Manual Intrastromal Keratopigmentation; G) Implantation of the brown pigment into the stromal pouch during the surgery; H) Immediate post-operative result.

Fig 3: A) Bilateral preoperative aspect showing leukocoria with corectopia and linear scar in OS; B) Bilateral aspect after 1 year KTP with combined technique; C) Slit lamp postoperative aspect; D) Immediate postoperative aspect.

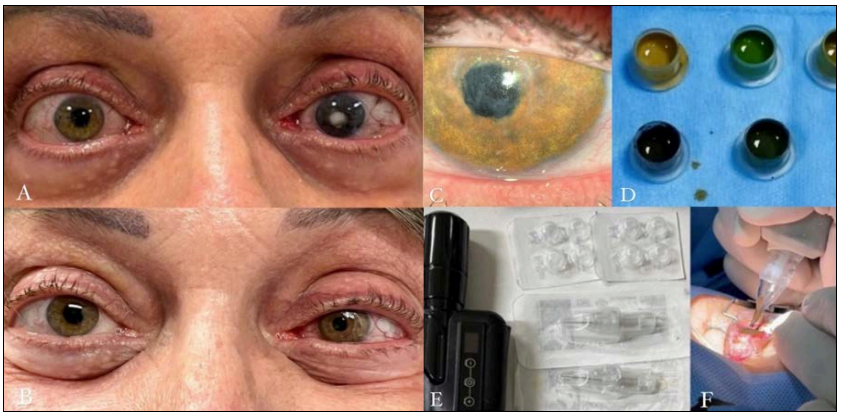

Fig 4: A) Bilateral preoperative aspect showing leukocoria with corectopia and hyperchromic iris in OS; B) Bilateral final aspect after superficial automated KTP; C) Slit lamp final aspect after KTP; D) Colors used in the Superficial Automated KTP; E) Dermograph and cartridges; F) Superficial Automated KTP in progress.

Conflict of Interest: Not available

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