Femtosecond-Assisted Keratopigmentation Double Tunnel Technique in the Management of a Case of Urrets-Zavalia Syndrome

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Purpose: To describe the successful use of a double intrastromal tunnel femtosecond-assisted keratopigmentation technique to manage a case of unilateral Urrets-Zavalia syndrome.

Methods: A 33-year-old man was referred with a history of trauma in his right eye due to a labor-related accident. Because of myopic anisometropia, he had been previously implanted with an angle-supported phakic intraocular lens. The patient presented iris atrophy and a fixed dilated pupil. He complained of severe and incapacitating photophobia, glare, and decreased vision. To obtain a complete iris replica, the surgery involved creation of double keratopigmented intrastromal tunnels using femtosecond laser and micronized mineral pigments. The deepest layer was stained black first and then the superficial layer was stained with a contoured greenish blue-gray color, which matched the contralateral eye.

Results: In the immediate postoperative period, the patient reported a complete elimination of photophobia associated with the corrected distance visual acuity improvement. A very adequate cosmetic outcome was also achieved. Stability was observed during the 12-month follow-up.

Conclusion: A femtosecond-assisted keratopigmentation technique using 2 pigmented intrastromal tunnels to achieve an intracorneal pigmented replica of the iris was effective in improving the patient's severe visual function disability and cosmetic appearance. To the best of our knowledge, this is the first report of severe visual function disability caused by atrophic iris and a fixed dilated pupil treated with double intrastromal layers of keratopigmentation by means of femtosecond-created tunnels.

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Keratopigmentation (KTP) or corneal tattooing has been used in the past to cosmetically restore severely impaired eyes.[1,2] Recently, KTP has also been reported to restore functional visual symptoms related to iris defects[3–6] and even intractable diplopia.[7]

Dilated and areflexic pupils with an atrophic iris are serious conditions with irritating and even incapacitating photophobia for young patients. The alternatives to solve these problems are limited to cosmetic contact lenses or intraocular surgery with or without lensectomy such as artificial iris prosthesis, intraocular diaphragm lens, or iris repair.[8,9]

We report an encouraging experience using KTP in a patient with a fixed dilated pupil (Urrets-Zavalia syndrome), an atrophic iris consecutive to an ocular trauma, and a phakic intraocular lens (IOL). The patient complained about severe incapacitating photophobia and glare. The patient was successfully treated with a femtosecond-assisted double tunnel and double-pigmented layer KTP technique. To the best of our knowledge, this is the first report to show the successful application of a double tunnel layer femtosecond-assisted KTP approach.

Surgical Technique

A 34-year-old man was referred to our clinic with an orbital fracture because of a contusive labor accident, which severely affected his right eye. The patient also had a phakic IOL previously implanted because of myopic anisometropia. The examination showed a fixed dilated pupil, sectorial iris atrophy, especially at the superior temporal and inferior zones and a light blue iris color on both eyes. An iris-fixated phakic IOL was properly placed, and a superior patent peripheral iridotomy was also observed (Figs. 1A, 2A). The patient suffered from incapacitating photophobia, glare, and decreased vision caused by the fixed dilated pupil. These symptoms improved with the use of sunglasses. Fundus examination showed a pale optic disk and commotio retinae involving the macula. The corrected distance visual acuity (CDVA) was 20/200. The intraocular pressure was normal,

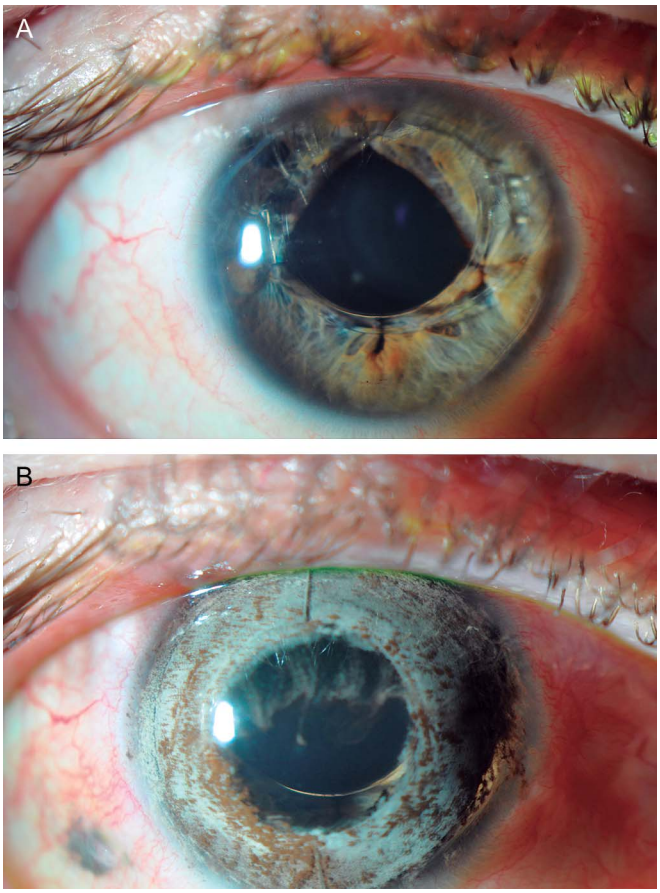

FIGURE 1. A, Preoperative frontal image obtained with a slit lamp of the case of Urrets-Zavalia syndrome shows a fixed dilated pupil and atrophic iris. B, Postoperative image shows the restoration of functional and cosmetic aspects using double tunnel FAK technique.

the gonioscopy examination showed a normal angle, and visual field showed a relative central scotoma. The examination of left eye was normal, with a CDVA of 20/20. The endothelial cell count was 2405 cells per square millimeter in the affected eye and 2410 cells per square millimeter in the contralateral eye.

After a comprehensive study of the case and an evaluation of all the potential treatments, the patient was informed about the possibility of femtosecond-assisted keratopigmentation (FAK) surgery as an alternative solution to a more traumatic intraocular surgery involving phakic IOL explantation, lensectomy, pseudophakic IOL implantation, and an artificial iris prosthetic system.

After a short negative experience with a cosmetic contact lens, the patient decided to follow with the FAK procedure, which was performed after obtaining an adequate informed consent.

Before the surgery, the local corneal thickness and tomography were measured in the different areas of the cornea by means of the time-domain Visante optical coherence tomography system (Carl Zeiss Meditec AG) to decide the appropriate lamellar depth for the 2 femtosecond tunnels.

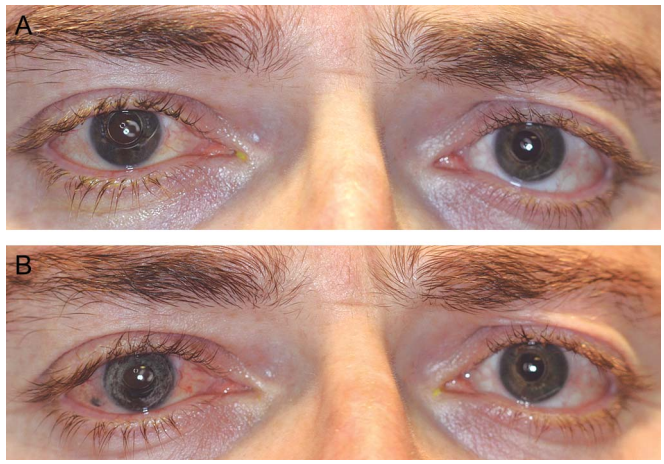

FIGURE 2. A, Binocular cosmetic appearance of the patient before surgery. B, Binocular cosmetic appearance of the same patient 3 months after surgery.

Pachymetry values obtained from the right eye were 603 μm for the range of 5 to 7 mm and 680 μm for 7 to 10 mm. Afterward, the white-to-white horizontal and vertical diameters were measured using a caliper to determine the diameter of the lamellar dissection. Because of the problem of the light iris color, we decided to create a double layer to mimic the normal anatomy of the iris (light-colored pigment applied to the superficial layer and a dark-colored pigment applied to the deepest layer).

The FAK surgical procedure was conducted under topical anesthesia (proparacaine hydrochloride 0.5%). The 2 intrastromal tunnels were created using the 60-kHz femtosecond laser (IntraLase AMO, Irvine, CA). The deepest tunnel was performed first at a 400 μm depth from the surface with an inner diameter of 6 mm and an outer diameter of 9.5 mm. The energy was set at 2 μJ, with a vertical incision at 6 o'clock hour. A second superficial tunnel was then performed at 200 μm depth, with an inner diameter of 6 mm and an outer diameter of 9.5 mm. The energy was set at 2 μJ with a vertical incision at 12 o'clock hour (Fig. 3). A lamellar dissector (KTP corneal dissector, Epsilon; Irvine, CA) was used to open the

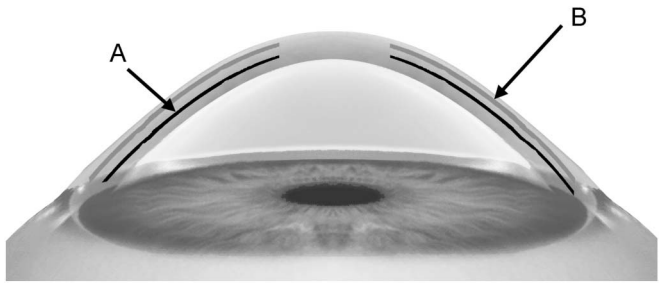

FIGURE 3. A, The deep darker layer to absorb the light and prevent it from entering the eye and hence eliminating visual function symptoms. B, Superficial light-colored layer that matches the color of the contralateral eye and hence improving the cosmetic appearance of the patient.

intralamellar femtosecond tunnels from each one of the incisions and to widen the outer diameter of the tunnels to the external limits of the cornea to reach the limbus. A specially prepared mineral micronized black pigment (Salvador Cordoba SL, Madrid, Spain, Spanish Ministry of Health Registration N° 279-PE/serie 1 and 281-PE/serie 3) was injected with a 27-gauge cannula into the deeper tunnel through the inferior incision (Fig. 4). The purpose of this black-stained tunnel was to re-create the role of the pigmentary epithelium of the iris. Then, a greenish blue-gray mineral micronized pigment was prepared to match the iris color of the other eye and injected through the superior tunnel. To re-create the cosmetic appearance of the eye, the customized superficial tunnel was stained and the peripheral cornea was treated in some areas with superficial automated keratopigmentation[5] to create an optimal cosmetic effect. The superficial automated keratopigmentation procedure was performed using a prototype of a punctural device (Vissum Eye MP System, Madrid, Spain; Apl. No. 2.949.539). Automatic micropunctures were performed, puncturing the superficial layers of the stroma to an approximate depth of 120 μm from the corneal surface. An adequate amount of the lighter micronized pigment was then injected. The penetration depth of the needles was controlled by the length of the longitudinal axial vibration of the tip.

A combination of topical antibiotics (ofloxacin 0.3%, Exocin; Alcon, Fort Worth, TX) and steroid (dexamethasone 0.1% Maxidex; Allergan, Irvine) was used as a postoperative topical therapy for 2 weeks. No postoperative adverse events were observed during the follow-up. Three months after the procedure, the CDVA was 20/115 and a complete elimination of the glare and photophobia was achieved and the cosmetic result was excellent (Figs. 1B, 2B). The vision remained low after the procedure because of macular atrophy as a result of the facial trauma. Despite the poor vision, the patient's quality of life improved as the photophobia, which prevented him from carrying out his daily working duties, was eliminated. No significant changes were observed at the 12-month follow-up.

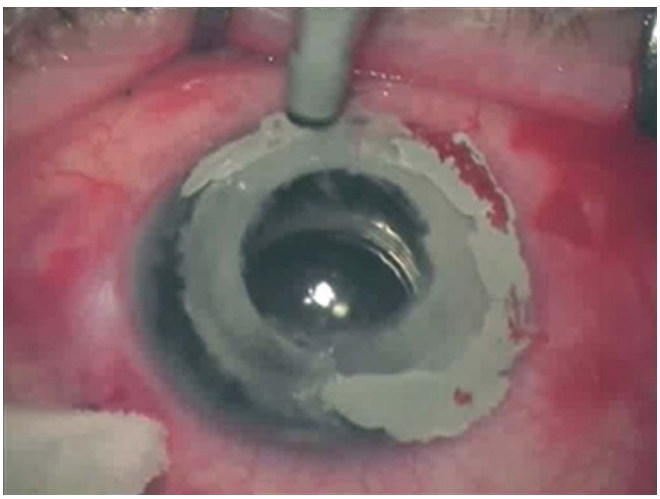

FIGURE 4. In this image, it is possible to see both tunnels in the cornea: a black pigmented deep layer and above a superficial greenish blue-gray pigmented layer.

DISCUSSION

Severe damage to the iris caused by ocular contusive trauma may produce a fixed dilated pupil in the affected eye (traumatic iridoplegia), also called Urrets-Zavalia syndrome.[10] In this case, the presence of an anterior chamber phakic IOL may have worsened the condition, causing iris atrophy and damaging the anatomical structure. The treatment options for this type of case are limited especially when the patient is contact lens intolerant as reported beforehand. A limited shielding capability for light was another complication provoked by the light-colored appearance of the patient's eye.

FAK is a novel technique that has been previously reported for the cosmetic restoration of blind eyes with disfigured corneal leukoma.[11,12] In this case, we successfully achieved both a cosmetic and functional restoration. The aim of the double-layer intrastromal KTP technique was to relieve both the visual symptoms and improve the cosmetic appearance of the eye. This was done by creating 2 separate layers: a deep darker layer to prevent the light from entering the eye with a shield effect and hence eliminating visual function symptoms and a superficial light-colored layer to match the color of the contralateral eye, hence improving the cosmetic appearance.

In conclusion, the double intrastromal KTP technique using femtosecond technology and customized mineral micronized pigments proved, in this difficult case, to be an excellent option to eliminate photophobia, glare, and visual impairment symptoms and to improve the cosmetic appearance of the patient's light pigmented iris. This case of a fixed dilated pupil with iris atrophy was an example of one of the indications of FAK for treating both incapacitating visual function disabilities by severe iris defects and improving cosmetic appearances.

The use of new micronized mineral pigments with an adequate toxicology study[1,13] is an essential step in the modern development of KTP. Our experience using this pigment in an experimental animal model and in patients has demonstrated it to be safe during a 2-year follow-up. Further investigations covering the long-term tolerance and stability of the mineral micronized pigments used for KTP procedures are needed before dissemination of the indication and practice of KTP techniques.

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