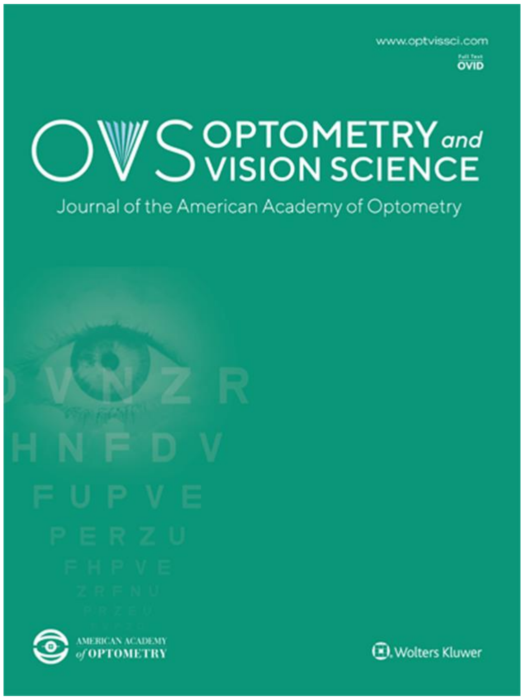

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CASE REPORT

Case Report: Role of Anterior Segment Optical Coherence Tomography for Managing Failed Endothelial Keratoplasty Graft

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ABSTRACT

Significance: Some patients show poor visual outcomes following Descemet stripping automated endothelial keratoplasty. In such cases, secondary Descemet membrane endothelial keratoplasty can be performed to achieve complete visual recovery. Anterior segment optical coherence tomography (AS-OCT) is a valuable tool for the follow-up of posterior lamellar keratoplasty outcomes and complications. **Purpose:** This study aims to report the clinical outcome of secondary Descemet membrane endothelial keratoplasty for managing poor visual results in a patient with graft failure after a previous Descemet stripping automated endothelial keratoplasty, highlighting the importance of AS-OCT in the follow-up of endothelial keratoplasty. **Case report**: A 38-year-old female with high myopia underwent Descemet stripping automated endothelial keratoplasty for bullous keratopathy following explantation of an angle-supported phakic intraocular lens. Two years after keratoplasty, the patient experienced poor visual acuity (counting fingers) and significant corneal edema was observed on clinical examination hindering visualization of the anterior chamber structures. AS-OCT (Casia 2) showed a failed and thickened graft adhering well to the recipient cornea in an anterior chamber without other comorbidities. Therefore, the graft was removed and replaced with a Descemet membrane endothelial keratoplasty graft without any complications. One year later, the clinical outcome was evaluated by comparing the preoperative and postoperative best-corrected visual acuity, biomicroscopy findings, endothelial cell density, and corneal central thickness. **Conclusions:** AS-OCT is an important tool when deciding on the surgical technique to be applied and for the postsurgical monitoring of endothelial corneal grafts. This case demonstrates the successful management of Descemet stripping automated endothelial keratoplasty graft failure with Descemet membrane endothelial keratoplasty graft, highlighting the importance of

AS-OCT in detecting complications such as graft dislocation and primary graft failure. Additionally, corneal thickness measured using AS-OCT serves as a critical predictor of graft failure, as observed in this case

Endothelial keratoplasty involves replacing a pathological corneal endothelium with a healthy donor endothelium, while preserving the unimpaired anterior corneal layers. Since 2006, there are two primary techniques for endothelial corneal transplantation: Descemet stripping automated endothelial keratoplasty, which is a more automated technique, and Descemet membrane endothelial keratoplasty, which is a wholly manual technique.[1-3]

The Descemet membrane endothelial keratoplasty technique is increasingly utilized due to the reported benefits when compared to Descemet stripping automated endothelial keratoplasty. First, the graft obtained in Descemet membrane endothelial keratoplasty is thin, consisting only of the Descemet membrane and endothelium, which allows for almost perfect anatomical and functional restoration of the host cornea. Second, it has been shown to achieve better and faster final visual acuity compared to Descemet stripping automated endothelial keratoplasty, as the resultant corneal architecture is optically neutral, inducing less refractive change and aberrations.[4,5] However, the difficulty in surgical manipulation of this endothelial graft means that Descemet stripping automated endothelial keratoplasty is still indicated in situations with comorbidity and intraoperative difficulties arising from the non-compartmentalization of the eye between the anterior and posterior segments. An example could be patients with uncontrolled ocular hypertension with glaucoma valves, complicated cataract surgery, and other situations that make anterior chamber pressurization difficult. The Descemet stripping automated endothelial keratoplasty graft is composed of not only the Descemet membrane and endothelium but also a posterior stromal layer of approximately 100 µm; therefore, it is debatable whether the increased thickness may limit the potential for complete functional restoration.[5] Some studies suggest that patients with low visual acuity after Descemet stripping automated endothelial keratoplasty may benefit from subsequent Descemet membrane endothelial keratoplasty to enhance functional recovery.[6]

Anterior segment optical coherence tomography (AS-OCT) has become an invaluable tool for preoperative diagnosis and post-surgical monitoring of patients with compromised corneal transparency. In such cases, visualization of anterior chamber structures, including the correct position and location of the endothelial graft, can be challenging. AS-OCT overcomes this limitation by providing real-time, noninvasive, high-resolution cross-sectional images of the anterior segment, even through an opaque cornea.[7,8]

This case report highlights the significance of using AS-OCT to monitor graft viability and promptly diagnose potential complications following Descemet membrane endothelial keratoplasty in patients with a history of decompensated Descemet stripping automated endothelial keratoplasty.

CASE REPORT

A 38-year-old female presented to our center with a complaint of photophobia and reduced visual acuity in her left eye. She had undergone refractive surgery for high myopia 18 years prior. Laser in situ keratomileusis was performed in the patient's right eye. However, given the -18 diopters of myopia in her left eye, an angle-supported phakic intraocular lens was implanted. Two years prior to presentation, she underwent phakic intraocular lens explantation, followed by cataract surgery by phacoemulsification with intraocular lens implantation in the capsular bag in her left eye. Despite the surgery, her visual acuity did not improve due to postoperative corneal edema caused by endothelial decompensation. She subsequently underwent Descemet stripping automated endothelial keratoplasty at a different medical center. The patient's chronological timeline is presented in Figure 1.

During the baseline visit, the patient exhibited a best-corrected visual acuity of 0.1 logMAR in her right eye, while her left eye had counting fingers at 1 meter. Slit-lamp examination showed pupillary ovalization and severe corneal edema in her left eye, hindering visualization of the anterior chamber structures (Fig. 2A). AS-OCT (Casia 2, version 3A.4; Tomey Corp, Nagoya, Japan) showed significant corneal edema with the graft adhering well to the recipient cornea, but the graft was found to be thicker than expected (>200 μm)[9]. The central corneal thickness was measured at 932 μm, with the host cornea encompassing 701 μm and the graft 231 μm (Fig. 2B and 2C). Non-contact specular microscopy (SP-2000P Topcon, Topcon Corp., Toyko, Japan) was unable to image the endothelial cells due to excessive edema masking specular reflection and hindering visualization of the corneal endothelium (Fig. 2D).

In view of endothelial graft failure and considering the quantification of anterior segment parameters by AS-OCT, we discussed three therapeutic options: conversion to penetrating keratoplasty, a new Descemet stripping automated endothelial keratoplasty, or conversion to Descemet membrane endothelial keratoplasty. At this point, AS-OCT played a valuable role in guiding the decision-making process. Significant corneal edema prevented visualization of the anterior chamber structures via slit lamp biomicroscopy. AS-OCT allowed imaging of the anterior chamber and assessment of important parameters such as a deep anterior chamber (3.62 mm) without anterior synechiae or vitreous, and the proper placement of the intraocular lens with appropriate compartmentalization of the eye between the anterior and posterior segments. Thus, as a better optical result is likely to be achieved with an isolated donor Descemet membrane transplant (as in Descemet membrane endothelial keratoplasty)[6], we considered the third option. Penetrating keratoplasty was ruled out due to the favorable findings observed with AS-OCT, allowing for a less invasive approach.

During the surgery, the thickened endothelial graft (Fig. 3A) was meticulously extracted from the posterior recipient stroma. Next, a 7.5 mm endothelial-Descemet membrane donor graft was inserted into the anterior chamber through a 3.2 mm superior corneal incision. The graft was gently manipulated with air and fluid until it was unfolded and oriented to the endothelial side down and spread out on the iris using the Melles *no-touch* technique.[10] The graft was then secured in place, and 20% sulfur hexafluoride gas was injected underneath it to fill the anterior chamber completely. The patient remained in a face-up position for 60 min. Following this, an air-liquid exchange with balanced salt solution was performed, leaving the anterior chamber filled two-thirds with gas. Both the surgery and immediate postoperative period were uneventful.

After the surgery, complete graft adhesion was observed under the gas with AS-OCT at the 24-hour mark, with persistent, predominantly stromal, corneal edema, and a 112 µm decrease in pachymetry compared to preoperative values (Fig. 3C and D). After 15 days, the operated eye showed a best-corrected visual acuity of 0.7 logMAR and a 201 µm decrease in the central corneal thickness (Figure 3E and F). After 2 months, the best-corrected visual acuity improved to 0.3 logMAR and the central corneal thickness decreased to 604 µm (Fig. 3G and H). After 6 months, the patient achieved 0.18 logMAR and the central corneal thickness decreased to 532 μm (Fig. 3I and J). Finally, after 1 year, the patient was asymptomatic, with a 0.1 logMAR and a 519 μm central corneal thickness (Fig. 3K and L). Figures 2E-H show images of the left eye of the patient 1 year after Descemet membrane endothelial keratoplasty surgery, using anterior segment biomicroscopy, AS-OCT, pachymetry, and specular microscopy, which revealed an endothelial cell count of 1230 cells/mm^2 with mild polymegathism.

DISCUSSION

AS-OCT has become an advantageous tool for decision-making and subsequent monitoring of anterior segment pathology. It is effective in managing endothelial keratoplasty, based on its ability to monitor pre- and postoperatively. This clinical case highlights the importance of AS-OCT, which illustrates how it aided in the selection of an appropriate surgical technique following endothelial failure of the initial transplantation, as well as in postoperative monitoring.

Since the introduction of these devices in 2005, their image capture speed and axial and transverse resolutions have improved. Currently, one of the most widely used commercially available devices in clinical practice is AS-OCT with Swept Source technology[11,12] such as the one used in our case, Casia 2 (Tomey Corp, Nagoya, Japan). The tomograph was specifically designed to capture images of the anterior ocular segment. It uses a 1310 nm wavelength laser, which is monochromatic and tunable, and a photodetector that captures interference signals. It also has high axial and lateral resolutions (≤ 10 μm and 30 μm, respectively).

Agha et al. demonstrated that Descemet membrane endothelial keratoplasty is a viable procedure for improving visual acuity in eyes with opaque corneas caused by corneal decompensation following Descemet stripping automated endothelial keratoplasty graft failure.[13] In this case, the use of AS-OCT allowed for accurate evaluation of a non-functioning graft (it had thickened), through an edematous and partially opaque cornea, with a thickness quantified at 231 µm (Fig. 2B). Additionally, AS-OCT provided an assessment of the irido-capsular diaphragm's integrity, which would have been impossible with only slit-lamp biomicroscopy or Scheimpflug imaging. This comprehensive evaluation allowed the authors to opt for Descemet membrane endothelial keratoplasty, which was performed without complications.

Following Descemet membrane endothelial keratoplasty surgery, AS-OCT facilitates the quantification of stromal corneal dehydration through pachymetry. As depicted in Figure 3, it enabled the authors to monitor stromal deturgescence and the consequent decrease in central corneal pachymetry, indicating the proper functioning of the endothelial Na^+/K^+ ATPase pump of the transplanted graft.

According to Yeh et al.,[14] postoperative AS-OCT has a potential predictive value for graft adherence at 6 months. In their study, 87 Descemet membrane endothelial keratoplasty-operated eyes were evaluated by AS-OCT at 60 min, 24 h, 1 week, and 1, 3, 6, 9, and 12 months postoperatively. Their findings suggest that AS-OCT at 60 minutes provides the highest positive predictive value (75%) for graft adherence status at 6 months, while AS-OCT at 1 week and 1 month provides 100% negative predictive value, indicating that if the graft is adherent, it will likely remain adherent in the long term and in these cases, if a delay in clearance is observed, any surgical procedure should be avoided. Therefore, the combined information from 1-hour and 1-week AS-OCT scans can facilitate decision-making regarding possible further surgical procedures after Descemet membrane endothelial keratoplasty. During the follow-up, AS-OCT was performed 24 hours, 15 days, and 2, 3, 6, and 12 months postoperatively. 20% sulfur hexafluoride gas was used at the end of surgery and maintained it for at least 24 hours, unlike Melles' group,[10] AS-OCT was not performed in the first postoperative hour because it only showed the almost total occupation of this gas in the anterior chamber. The authors believe that AS-OCT, along with specular biomicroscopy, is important for long-term postoperative follow-up to assess graft failure, which manifests as an increase in corneal pachymetry due to stromal edema and endothelial cell loss.

In addition, AS-OCT is a valuable tool in diagnosing the main complication of Descemet membrane endothelial keratoplasty in the early postoperative period: the early partial or total detachment of the graft to the recipient stroma.[15,16] While it may be possible to visualize this complication with slit-lamp biomicroscopy, severe corneal edema can make it difficult to accurately diagnose and even mistake it for delayed corneal clearance.[7,8] AS-OCT is especially helpful in cases of corneal opacity, as an accurate assessment of the degree of detachment is necessary to make a decision between observation of the clinical course or early planning of rebubbling or retransplantation, where time is critical. At our center, this complication is managed following the indications described by Melles' group:[16] in the case of partial detachments of ≤1/3 of the graft surface and without visual axis involvement, we simply observe, but in those with >1/3 or visual axis involvement, we perform rebubbling with air or 20% sulfur hexafluoride gas before 6 weeks post-op to prevent graft adhesion failure owing to increased graft stiffness and scarring. When the grafts are free-floating in the anterior chamber or inverted, we perform early re-Descemet membrane endothelial keratoplasty to avoid subepithelial fibrosis and the inability to repeat this surgery due to limited visualization.[16] For applied grafts with delayed corneal clearance, AS-OCT again plays a fundamental role in monitoring qualitative and quantitative stromal dehydration by pachymetry.

In this case, the utilization of AS-OCT was beneficial both pre- and post-operatively. Owing to its non-invasiveness and clinical performance, AS-OCT should be considered in all corneal units for accurate assessment and management of Descemet membrane endothelial keratoplasty complications".[13]

CONCLUSIONS

AS-OCT is a valuable tool in the decision-making process and post-surgical monitoring of endothelial transplantation procedures. In this case, Descemet membrane endothelial keratoplasty was a successful procedure for salvaging endothelial failure after Descemet stripping automated endothelial keratoplasty. Furthermore, corneal pachymetry monitoring with AS-OCT is a good predictor of graft function and possible graft failure.

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FIGURE LEGENDS

Figure 1. Clinical timeline: A 38-year-old female is diagnosed and surgically treated for Descemet stripping automated endothelial keratoplasty graft failure. All findings pertain to the left eye. BCVA = best-corrected visual acuity; CF = counting fingers; DSAEK = Descemet stripping automated endothelial keratoplasty; AS-OCT = anterior segment optical coherence tomography; CESM = corneal endothelial specular microscopy; CCT = central corneal thickness; DMEK = Descemet membrane endothelial keratoplasty.

Figure 2. Comparison of anterior segment photographs, AS-OCT, pachymetry, and specular microscopy before and 1 year after Descemet membrane endothelial keratoplasty surgery. **(A)** Slit-lamp biomicroscopy photograph of the left eye (at the baseline) showing severe stromal corneal edema. **(B)** Anterior segment optical coherence tomography (AS-OCT) image (Case 2) shows stromal edema of the recipient cornea and decompensated and thickened donor graft. **(C)** Baseline corneal pachymetry shows a central corneal thickness of 932 µm. **(D)** Specular microscopy was unable to image endothelial cells due to excessive edema masking specular reflection and hindering visualization of the corneal endothelium. **(E)** Slit-lamp biomicroscopy photograph of the left eye 1 year after Descemet membrane endothelial keratoplasty showing a clear cornea without edema. **(F)** An AS-OCT image showing perfect graft adhesion and edema-free cornea. **(G)** Final corneal pachymetry shows a central corneal thickness of 519 µm. **(H)** Specular microscopy reveals an endothelial count of 1230 cells/mm2 with mild polymegathism.

Figure 3. A series of Anterior segment optical coherence tomography (AS-OCT) and pachymetry images (Case 2) of the left eye from the baseline visit up to 1 year after Descemet membrane endothelial keratoplasty. **(A-B)** Baseline visit showing a central corneal thickness of 932 µm. **(C-D)** AS-OCT at 24 hours postoperatively with adherent graft and 820 µm central

pachymetry. **(E-F)** AS-OCT at 15 days showing a significant decrease of stromal edema with a central corneal thickness of 731 µm. **(G-H)** At 2 months with 604 µm central corneal thickness. **(I-J)** At 6 months with 532 µm central corneal thickness. **(K-L)** At 1 year with 519 µm.

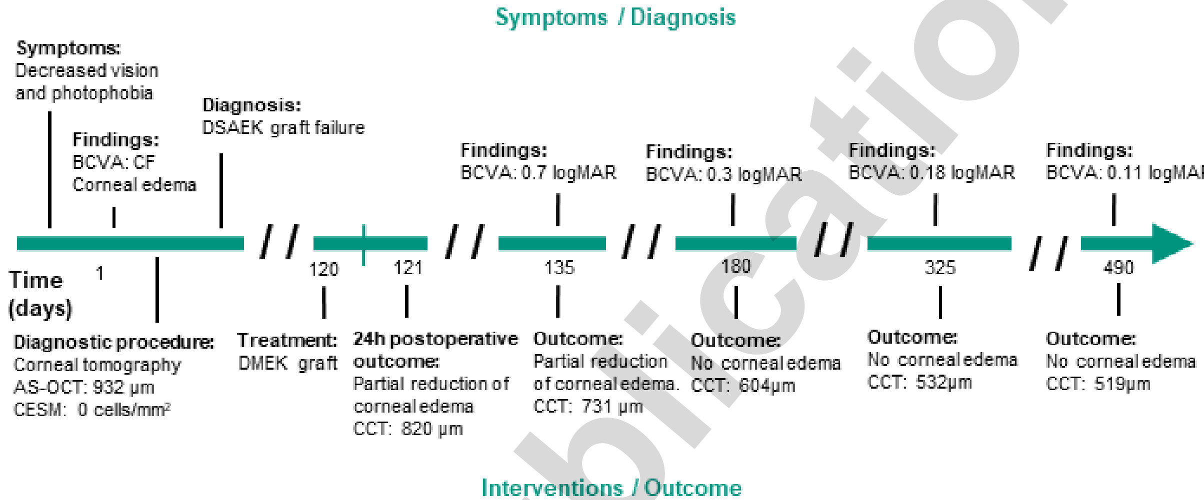
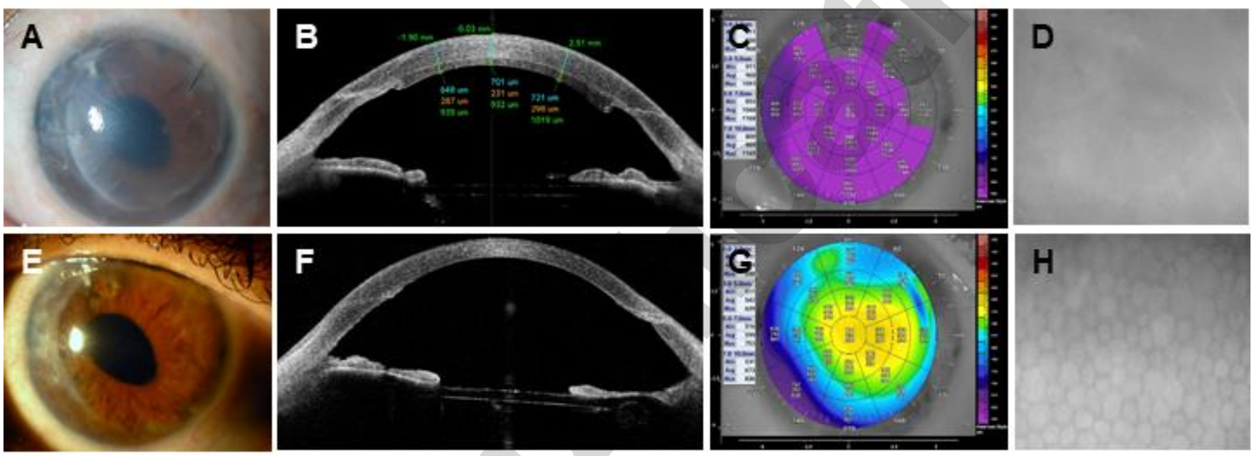


Figure 1. Clinical timeline: A 38-year-old female is diagnosed and surgically treated for DSAEK graft failure. All findings pertain to the left eye. Abbreviations: BCVA, best-corrected visual acuity; CF, counting fingers; DSAEK, Descemet stripping automated endothelial keratoplasty; AS-OCT, Anterior segment optical coherence tomography; CESM, Corneal endothelial specular microscopy; CCT, Central corneal thickness; DMEK, Descemet Membrane Endothelial Keratoplasty.



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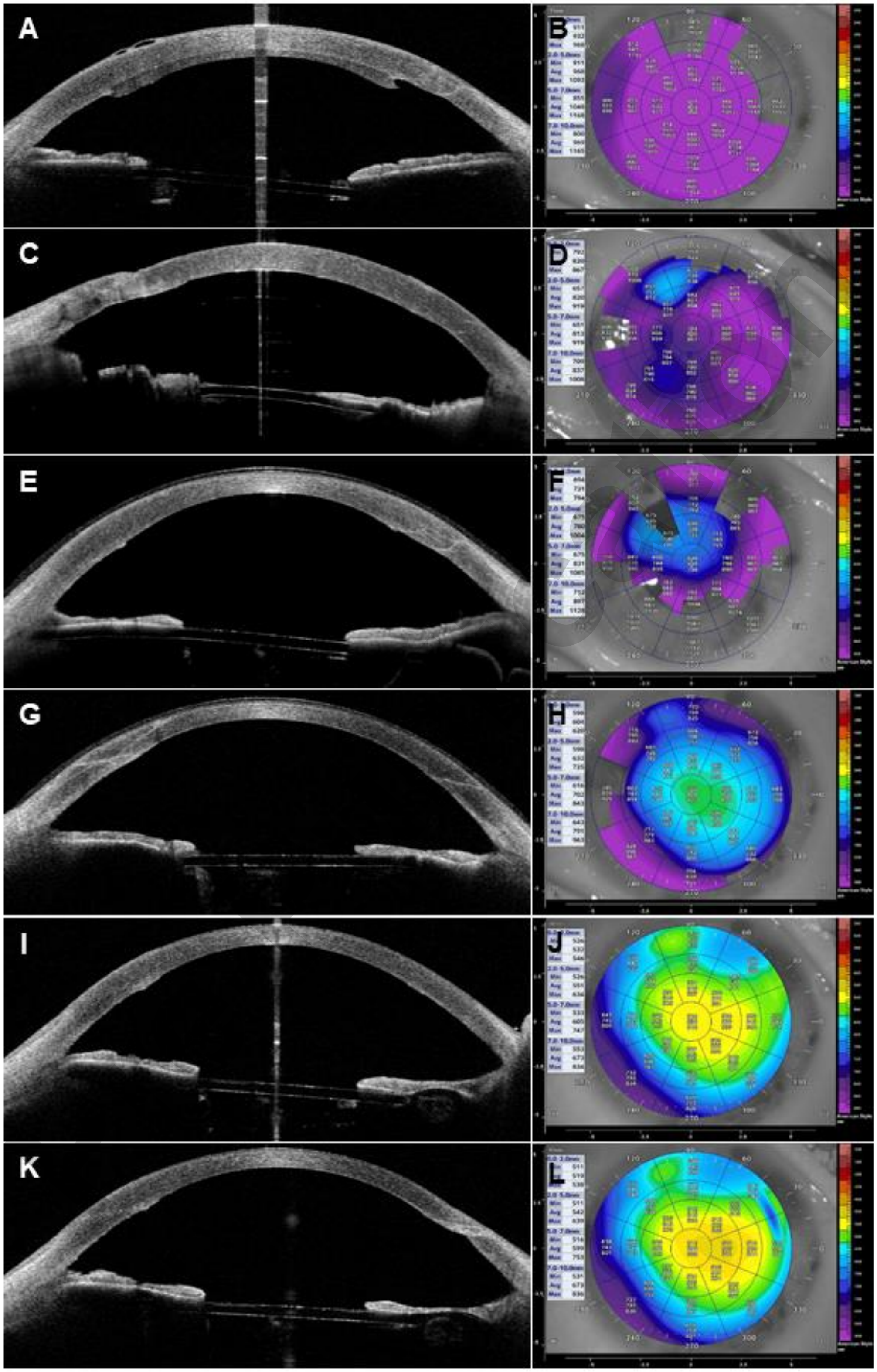

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