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Anterior segment ocular coherence tomography: A practical tool for the comprehensive ophthalmologist

Matthew Bujak, MD, FRCSC and Arshdeep Marwaha, BSc.

INTRODUCTION

Ocular coherence tomography (OCT) provides non-invasive and rapid in vivo imaging of ocular structures using low coherence interferometry. It first appeared in 1991 for imaging of the posterior segment of the eye; shortly thereafter, the utility of OCT was expanded to the anterior segment (AS-OCT).[1] With improvements in technology including higher resolution and rapid capture speed of images, AS-OCT has become an integral tool for current-day cornea specialists in the clinical evaluation of the cornea and anterior segment. AS-OCT pachymetry is often used to analyze corneal thickness while cross-sectional images assist with the visualization and morphometric analysis of the anterior segment.[1] These features are commonly used to assess endothelial graft attachment and corneal graft health. Though AS-OCT has been used predominately by cornea specialists, it does have wide-spread application for the comprehensive ophthalmology practice. Moreover, the advent of affordable imaging attachment lenses has also made AS-OCT a more practical tool to have in the clinic.

A comprehensive ophthalmologist can use AS-OCT to monitor pathologies such as recurrent corneal erosions, Salzmann Nodular Degeneration, depth of scarring and endotheliitis.[2–5] It can also be used in the pre- and post-operative assessment for cataract surgery. For example, AS-OCT can be used to help assess the likelihood of whether a patient with Fuchs' dystrophy may develop corneal decompensation following cataract surgery. This information can in turn help navigate shared clinical decision making by informing the patient about the risks and benefits of surgery pre-operatively. In the post-operative setting, mild corneal edema is common and expected. However, if there is edema which is out of proportion to either the surgeon's expectations or the amount of energy from the surgery, a closer look to find the etiology of the edema is warranted. AS-OCT can be used to help delineate common causes of corneal decompensation following cataract surgery including Descemet's membrane (DM) detachment, retained lens fragments, or infectious causes.[6,7] We present four clinical scenarios, one of which is the use of AS-OCT in pre-operative assessment and three cases in which AS-OCT is used to identify post-operative complications.

CASE 1: FUCHS' DYSTROPHY AND CATARACT SURGERY

Patients with Fuchs' dystrophy have progressive deterioration of endothelial cell density which leads to corneal edema, scarring, and decreased visual acuity. This is of particular concern when considering cataract surgery, as intraocular surgeries can accelerate loss of endothelial cell count. Preoperative assessment and suitability for cataract surgery of patients with Fuchs' is therefore imperative in screening for ideal candidates and to avoid causing worsening of edema and corneal decompensation in high-risk patients. AS-OCT pachymetry of the cornea is an excellent tool to quantify edema or corneal haze in patients both pre- and post-operatively, which serves as a surrogate marker for endothelial cell health.[8] AS-OCT can be utilized to determine whether cataract surgery alone (i.e. without DMEK/CE/PCIOL) will suffice for correcting vision. We applied this imaging modality for pre-operative screening to an 80-year-old female with Fuchs' dystrophy who was referred to our clinic for cataract surgery. Her OCT showed slight epithelial thickening from borderline edema (**Figure 1A**). We were able to utilize our OCT image to discuss the risks and benefits of performing cataract surgery without corneal transplant, while also addressing the risk of post-operative corneal edema with the patient. The patient ultimately decided on cataract surgery alone, but the pre-operative assessment utilizing OCT enabled us to provide the patient with realistic expectations following surgery and a good understanding of the inherent risks of endothelial decompensation.

CASE 2: DESCEMET'S MEMBRANE (DM) DETACHMENT POST CATARACT SURGERY

DM detachment typically occurs during cataract surgery but may not be evident until the post-operative visit. It leads to edema which if not treated promptly may lead to corneal scarring and decreased vision. We assessed a 62-year-old female who had an otherwise unremarkable routine cataract surgery. She was referred to our clinic three months after surgery with persistent corneal edema and 20/100 visual acuity OS. The extent and length of the period over which the edema persisted were considered abnormal. AS-OCT pachymetry demonstrated significant corneal thickening (**Figure 2A**). Cross-section AS-OCT revealed a focal detachment of the DM at the site of the corneal incision made during surgery (**Figure 2B**). An injection of air into the anterior chamber (i.e. descemetopexy) was performed as a tamponade to

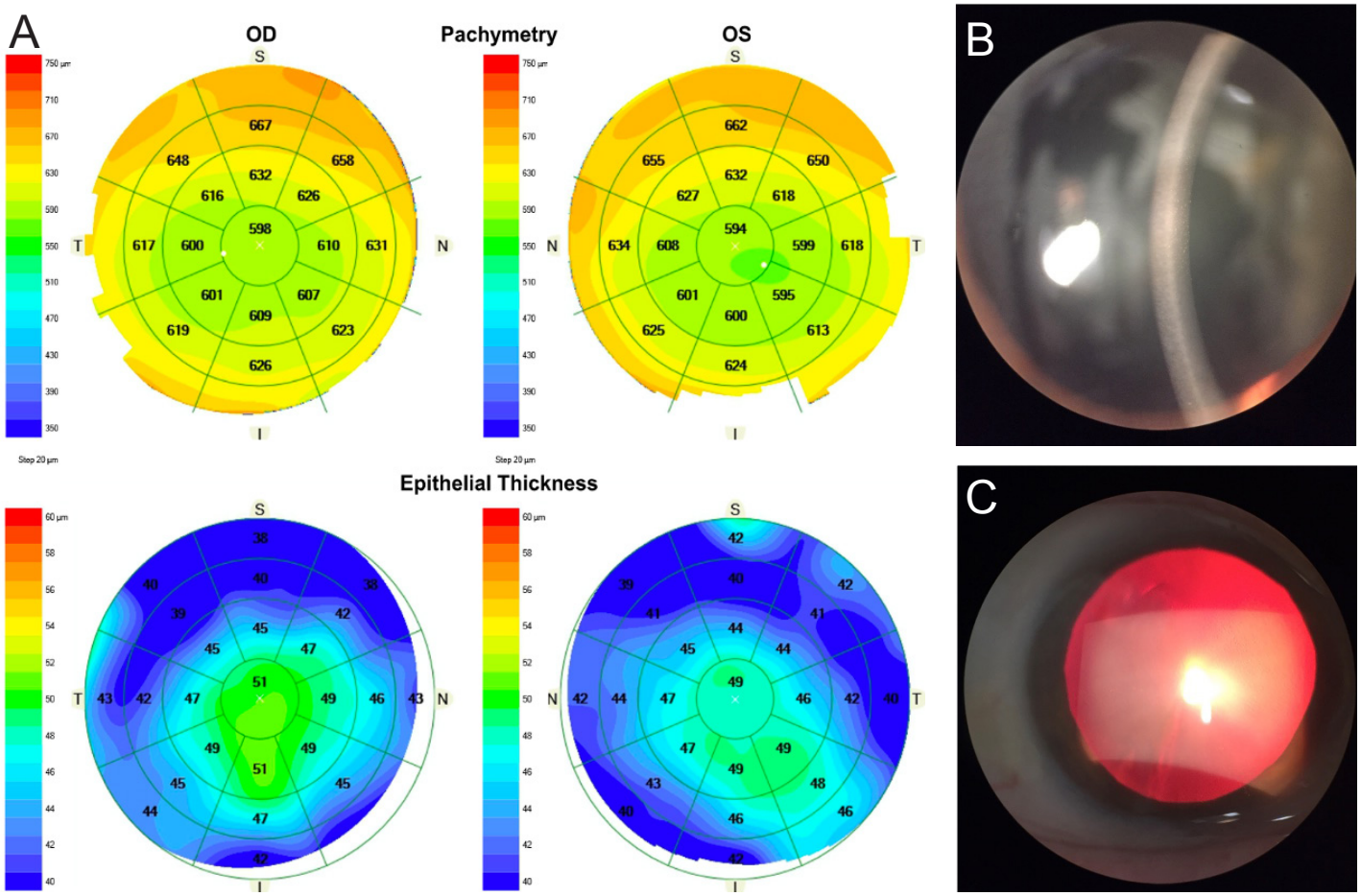


Figure 1: *Fuchs' Dystrophy and cataract surgery. (A) AS-OCT pachymetry showing diffusely increased corneal thickness OU. (B) Cornea photograph displaying 1+ guttata. (C) Clear-appearing cornea under direct light.*

promote adherence of the Descemet membrane against the stroma. This procedure transiently cleared the edema but ultimately did not result in reattachment of the DM, necessitating further surgical intervention. A DMEK was done, which failed to re-attach the endothelium, likely because of the chronic fibrosis on the posterior corneal interface. A DSAEK was subsequently performed but unfortunately only moderate improvement in visual acuity was observed as substantial interface corneal scarring and fibrosis had already occurred.

DM detachment can be missed during cataract surgery. Furthermore, post-operative corneal edema can be difficult to quantify on slit-lamp examination alone. This case illustrates how early postoperative use of AS-OCT could have identified the cause of the corneal edema and led to a prompt solution without corneal transplantation and the possibility of an improved visual outcome.

CASE 3: RETAINED LENS FRAGMENT POST CATARACT SURGERY

A retained lens fragment is a potential serious complication of cataract surgery. Patients can develop elevated intraocular pressures, eye pain, and blurry vision from corneal edema. In keeping with these symptoms, a 70-year-old female initially presented with good vision after cataract surgery but two weeks thereafter, she complained of right eye discomfort and blurry vision. Clinically, the patient's anterior segment on slit-lamp examination showed subtle inferior corneal edema (**Figure 3B–C**); however, AS-OCT pachymetry demonstrated stromal and epithelial thickening at the inferior aspect (**Figure 3A**). This imaging modality confirmed clinical corneal edema which was missed on routine examination. The inferior location of the edema prompted a gonioscopic exam which identified a retained nuclear lens fragment. This fragment was promptly removed the following day via surgery prior to the development of any complications. The patient was subsequently monitored for resolution of her corneal edema using AS-OCT pachymetry (**Figure 3D–F**). Fortunately, the retained fragment was retrieved in a timely manner before any significant endothelial decompensation had occurred, allowing our patient to regain 20/20 uncorrected vision after surgery.

CASE 4: HERPES SIMPLEX VIRUS (HSV) AFTER CATARACT SURGERY

Surgical trauma in addition to topical corticosteroid use which is routinely prescribed after cataract surgery can lead to development of HSV keratitis in rare cases. A 57-year-old male presented in our clinic four months after femtosecond laser cataract surgery with worsening vision and focal corneal edema at the wound margin and keratic precipitates. There were no retained fragments on gonioscopy. The AS-OCT showed no DM detachment but pachymetry did reveal corneal edema (**Figure 4A-B**). His clinical picture was unclear, but consistent with a possible

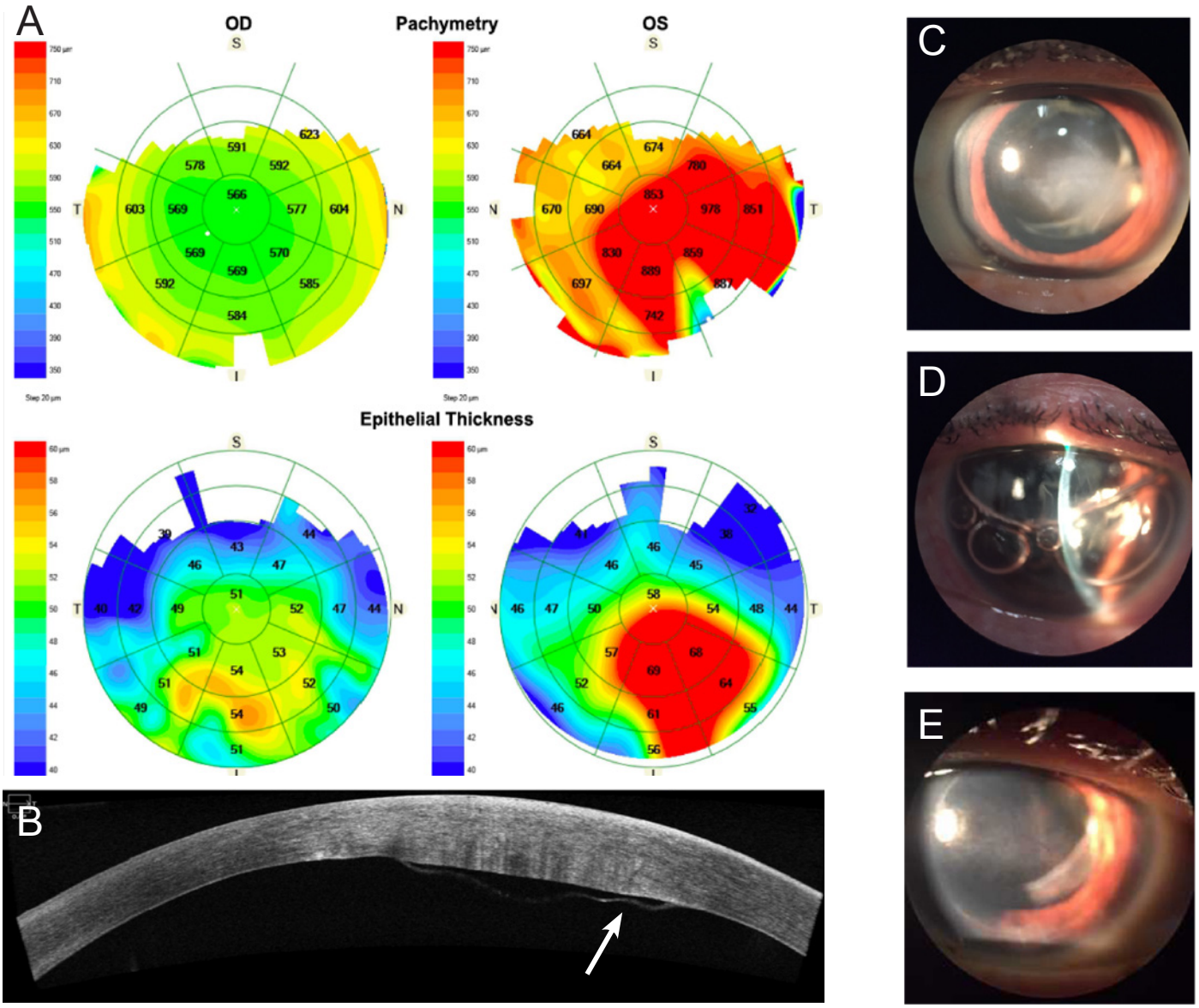
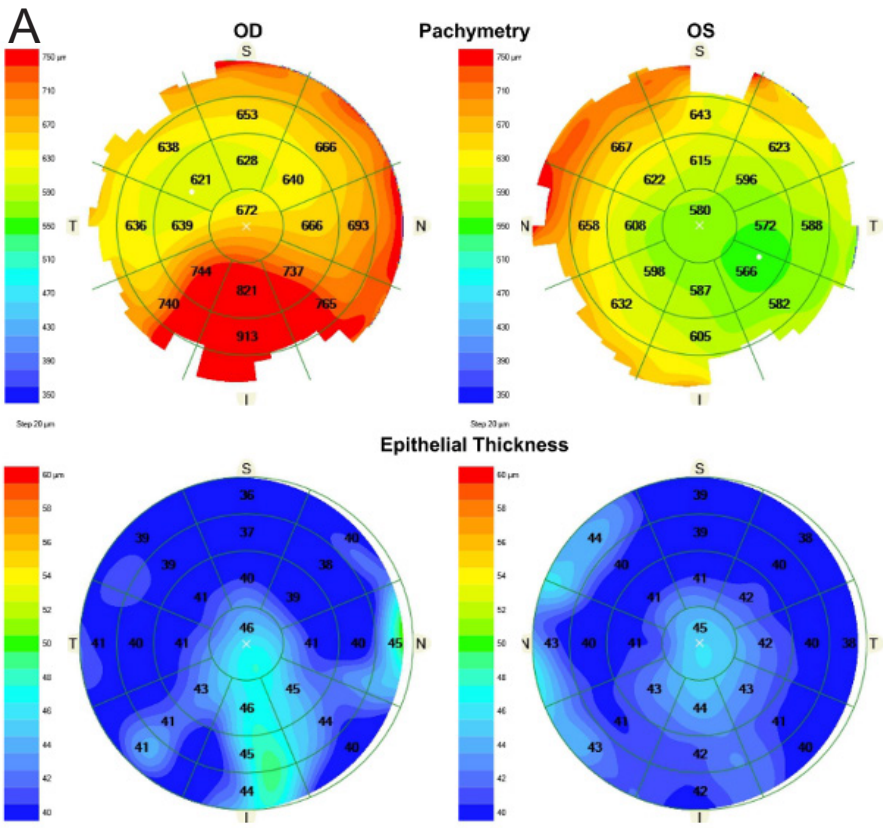


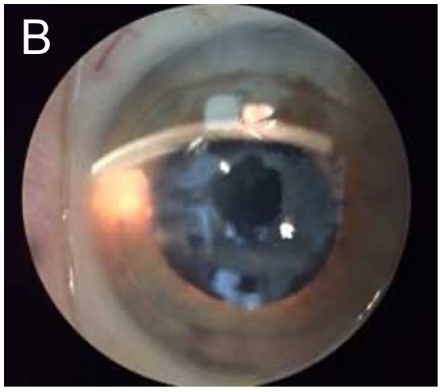
Figure 2: *Descemet's Membrane Detachment post cataract surgery. (A) AS-OCT pachymetry showing increased corneal and epithelial thickness inferotemporally OS. (B) AS-OCT image of cornea. White arrow indicates Descemet's Membrane detachment. (C) Cornea photograph at initial presentation, (D) following descemetopexy, and (E) after DSAEK.*

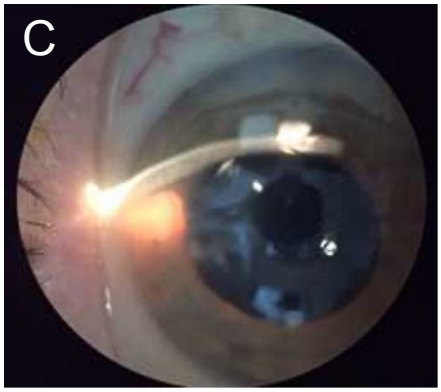
avulsion of DM or with an unresolved HSV infection. We elected to treat for the presumed HSV infection with steroids, valacyclovir 500 mg oral tablets three times daily for 10 days and then once daily for several weeks thereafter. We closely monitored the patient with AS-OCT pachymetry. Repeat imaging at 4 weeks post-valacyclovir initiation (**Figure 4C–D**) showed that the patient's corneal edema had resolved with secondary stromal vascularization and decreased corneal sensation, supporting our working diagnosis. This case illustrates the use of AS-OCT cross-section imaging and pachymetry in ruling out certain pathologies (i.e. DM detachment) whilst also providing a quantitative measure to follow the progress of a patient's treatment course and effectiveness of the treatment plan.

CONCLUSION

AS-OCT is an excellent non-contact tool that provides high resolution imaging of structures extending from the corneal epithelium to the ciliary body, facilitating the diagnosis and management of various anterior segment pathologies. Currently, this imaging modality is underutilized in the general ophthalmology clinic. However, given its broad application, the incorporation of AS-OCT has the potential to improve diagnostic certainty, decrease the need for referral to ophthalmology subspecialists, and enhance overall patient care.







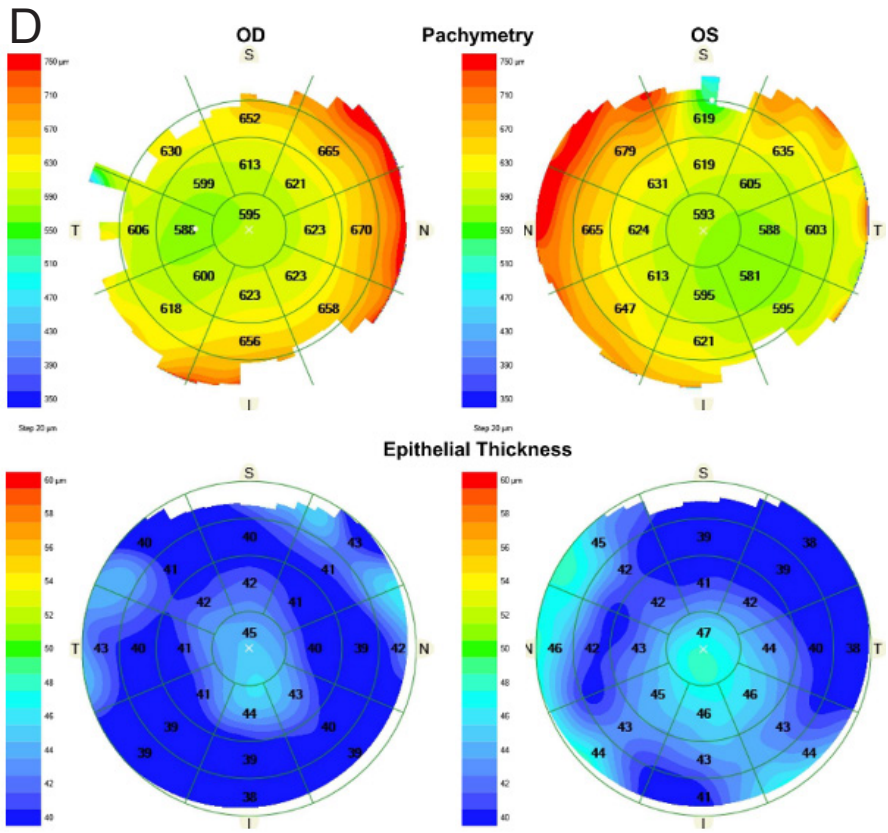


Figure 3: *Retained nuclear fragment following cataract surgery. (A) AS-OCT pachymetry showing increased corneal thickness inferiorly OD 2 weeks after cataract surgery. (B) and (C) Cornea photographs displaying mild corneal edema at initial presentation. (D) Resolved corneal edema 3 weeks after surgical removal of retained nuclear fragment.*

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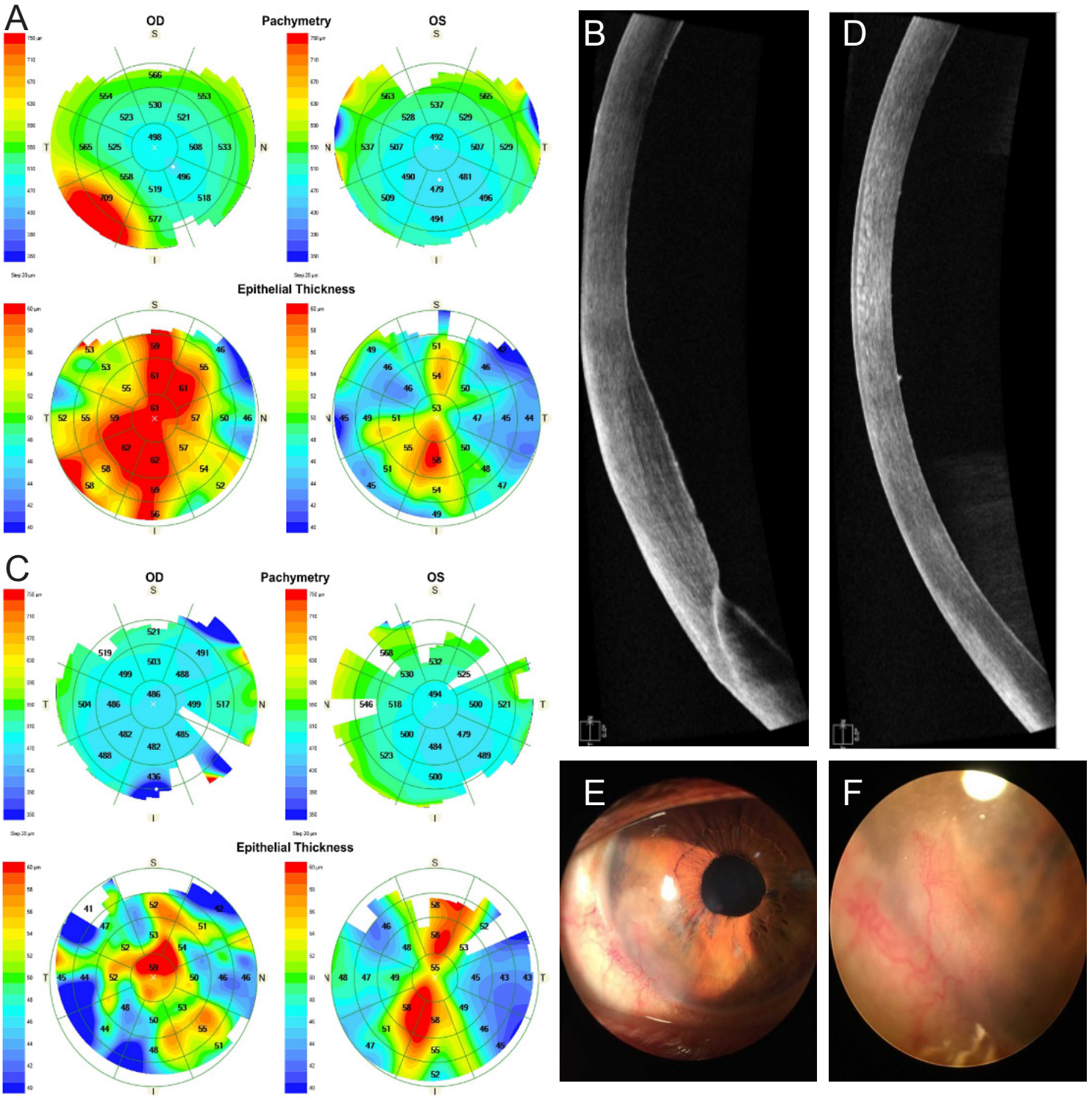

Figure 4: *Herpes Simplex Virus infection following femtolaser cataract surgery. (A) AS-OCT pachymetry anterior segment imaging (B) showing increased corneal thickness in the inferotemporal cornea OD, (C) and (D) thickness resolved following steroid and anti-viral therapy. (E) Residual stromal scarring and vascularization adjacent to wound margin and (F) neovascularization of cornea.*