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CASE REPORT
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Identification of a Single Zonular Fiber Preserving Aqueous Outflow under Extensive Posterior Synechiae in a Bitch: The Potential Diagnostic Value of Ultrasound Biomicroscopy

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ABSTRACT

***Background*:** This report describes a rare postoperative situation in which nearly circumferential posterior synechiae developed secondary to postoperative uveitis, yet pupillary block and intraocular pressure elevation were prevented. This outcome was attributed to a single anteriorly displaced zonular fiber that maintained focal separation between the iris and the anterior lens capsule, thereby preserving localized aqueous humor outflow. This study aimed to use ultrasound biomicroscopy to structurally characterize this atypical aqueous outflow pathway and to emphasize the clinical importance of identifying subtle postoperative outflow routes.

***Case*:** A 13-year-old spayed bitch Pomeranian underwent phacoemulsification for an intumescent cataract in the right eye. Preoperative evaluations, including ultrasound biomicroscopy, ocular ultrasonography, specular microscopy, and electroretinography, revealed no abnormalities that would contraindicate surgery, aside from a narrowed iridocorneal angle. The procedure proceeded without complications and included placement of a capsular tension ring due to an intraoperatively identified zonular fiber suggestive of zonular instability, followed by in-the-bag intraocular lens implantation. In the immediate postoperative period, a slight leak from the main port caused transient hypotony, accompanied by a small corneal ulcer and anterior chamber inflammation. All of these complications responded to medical treatment. On postoperative day 14, a single zonular fiber was observed protruding anteriorly and contacting the corneal endothelium at the 5 o'clock position. At postoperative month 1, intracameral tissue plasminogen activator was administered; however, no change in the protruding zonular fiber was observed. By postoperative month 2, slit-lamp examination revealed nearly 360° posterior synechiae, yet the intraocular pressure remained within the low-normal range, and the iris maintained a flat contour. Ultrasound biomicroscopy demonstrated a small residual gap between the iris and anterior lens capsule at the 5 o'clock region, maintained by the anteriorly displaced zonular fiber. Because the eye remained comfortable and the zonular fiber appeared to preserve aqueous outflow, zonulectomy was not performed. Between postoperative months 4 and 6, anterior chamber inflammation gradually improved, intraocular pressure remained stable at 7 mmHg, and no glaucoma or retinal complications developed. However, focal corneal lipid deposition appeared at postoperative month 5, likely associated with long-term corticosteroid use, and was managed by adjusting medical therapy.

***Discussion*:** This case demonstrates, based on ultrasound biomicroscopy findings, that a single zonular fiber can function as a mechanical spacer, preventing complete posterior synechial closure and maintaining aqueous humor flow in situations where pupillary block would otherwise be expected. While vitreous wick syndrome in humans also involves anteriorly displaced intraocular structures that affect aqueous dynamics, the mechanism in this case differed, as the thin zonular fiber appeared to preserve rather than obstruct aqueous passage. This case emphasizes the diagnostic value of ultrasound biomicroscopy in identifying subtle postoperative structural variations that may critically influence aqueous humor outflow. It also illustrates how imaging can clarify discrepancies between clinical expectations and physiological behavior, potentially preventing unnecessary interventions such as synechiolysis, iridectomy, zonulectomy, or early glaucoma surgery. Although limited to a single case, this report highlights the potential diagnostic value of ultrasound biomicroscopy in understanding atypical postoperative aqueous humor dynamics. It may inform imaging-guided clinical decision-making in similar cases in the future.

Keywords: anterior segment imaging, aqueous humor dynamics, cataract surgery, posterior synechiae, ultrasound biomicroscopy, zonular fiber.

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INTRODUCTION

Phacoemulsification is the standard treatment for canine cataracts and usually yields favorable visual outcomes. However, postoperative complications such as ocular hypertension, persistent uveitis, intraocular hemorrhage, retinal detachment, and glaucoma can limit long-term success [7,10]. Persistent uveitis is particularly important because it promotes posterior synechiae between the iris and anterior lens capsule, which may cause pupillary block, impaired aqueous humor flow, iris bombé, and secondary angle closure when circumferential [12,16,20].

Identifying disturbances in aqueous humor flow is essential in these scenarios. Slit-lamp biomicroscopy often lacks sufficient resolution to detect changes masked by media opacity, inflammation, or structural anomalies. In contrast, ultrasound biomicroscopy (UBM) enables detailed cross-sectional imaging of the anterior segment, including the iridocorneal angle, ciliary cleft, lens, iris, and ciliary body, making it a valuable diagnostic tool in complex postoperative cases [6,14,15].

This report describes a unique postoperative presentation in which nearly circumferential posterior synechiae did not result in pupillary block. UBM revealed a single anteriorly displaced zonular fiber that maintained a focal separation between the iris and anterior lens capsule, preserving segmental aqueous outflow. This structural feature, which could not be identified through routine ophthalmic examination, was considered responsible for preventing angle closure and maintaining normal intraocular pressure. This case emphasizes the value of UBM in assessing atypical aqueous outflow pathways and guiding postoperative clinical decision-making.

CASE

A 13-year-old spayed bitch Pomeranian, weighing 3.5 kg, was referred for evaluation of a cataract in the right eye (OD). The patient was systemically stable, with normal temperature (38.9°C), heart rate (114 bpm), respiratory rate (32 bpm), blood pressure (SBP 143 mmHg), and blood glucose (77 mg/dL). No underlying medical conditions were identified. Neuro-ophthalmic examination revealed normal menace response, dazzle reflex, and pupillary light reflex (PLR). The Schirmer tear test (STT)[1] was 13 mm/min OD, and intraocular pressure (IOP) measured by rebound tonometry[2] was 17 mmHg. Slit-lamp biomicroscopy[3] showed mild conjunctival hyperemia and an intact corneal epithelium. Regarding intraocular inflammation, only a trace aqueous flare was present without anterior chamber (AC) cells. The lens exhibited a late immature to early mature cataract with formation of a cleft along the anterior Y-suture (Figure 1A, B & C).

Specular microscopy[4] showed an endothelial cell density of 1,956 cells/mm². Ocular ultrasonography[5] with a 4-18 MHz linear array transducer confirmed lens thickening (9.16 mm), vitreous degeneration, and absence of retinal detachment (Figure 1D). UBM[6] revealed a narrowed iridocorneal angle (ICA) [Figure 2A]. Electroretinography (ERG)[7] demonstrated mildly reduced but preserved retinal function. These findings supported a diagnosis of an intumescent cataract. Given the associated risk of capsule rupture and secondary angle closure, prompt cataract surgery was recommended, and phacoemulsification was planned.

Under general anesthesia, a 3.0 mm clear corneal main port and a side port incision were created. The anterior capsule was stained with trypan blue[8], and a 6.0 mm continuous curvilinear capsulorrhexis (CCC) was completed. After hydrodissection with balanced salt solution (BSS)[9], a capsular tension ring (CTR, 13 mm)[10] was inserted to stabilize the capsule. Phacoemulsification was performed using the divide-and-conquer technique with a phacoemulsification machine[11], and a foldable intraocular lens (IOL, 12 mm)[12] was implanted into the capsular bag. Residual viscoelastic material[13] was removed with irrigation and aspiration (I/A), the main incision was closed with a single interrupted 8-0 polyglactin suture[14]. At the end of surgery, subconjunctival dexamethasone sodium phosphate[15] and 0.5% moxifloxacin[16] were injected.

On the day of surgery, IOP was 18 mmHg. The following day, IOP decreased to 4 mmHg due to a slight leak from the main port (Seidel test positive). Concurrent findings included a superolateral corneal epithelial ulcer with mild edema, AC inflammation (flare 3+, AC cells 3+), and anterior vitreous prolapse (inferomedial quadrant). After epithelial debridement and bandage lens[17] placement, antimicrobial and anti-inflammatory treatment was initiated while avoiding topical corticosteroids. By postoperative day (POD) 2, leakage had resolved (Seidel test negative), and IOP increased to 12 mmHg. The ulcer healed (fluorescein stain test negative), but AC inflammation persisted.

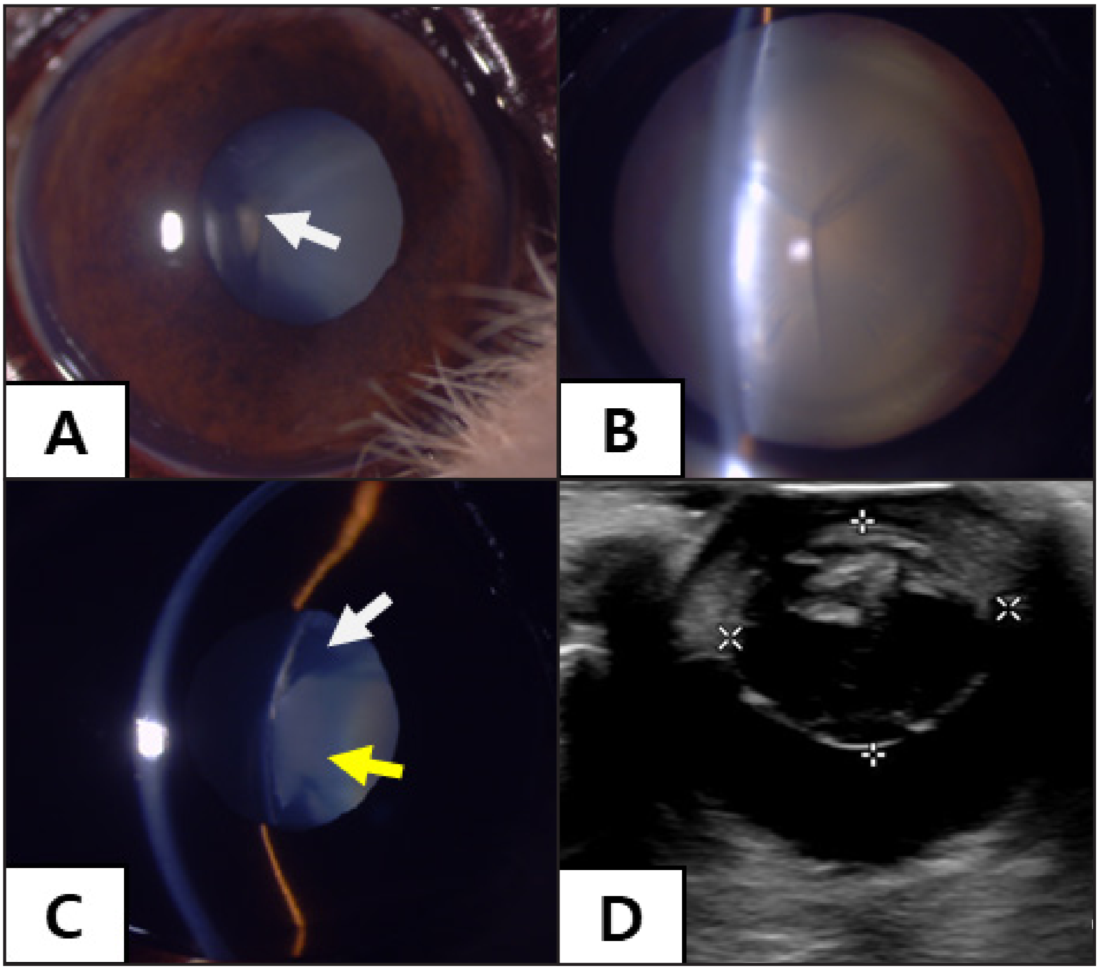

Figure 1. Preoperative slit-lamp and ultrasonographic findings of the right eye (OD). A- Diffuse slit-lamp image before mydriasis (magnification, x10) showing separation of the Y-suture (water cleft) observed in the lens (white arrow), which is consistent with an intumescent cataract. B- Retroillumination slit-lamp image after mydriasis (x10) demonstrating poor light transmission through the lens, with the tapetal reflex barely detectable. C- Diffuse slit-lamp image before mydriasis (x10), with the white arrow indicating intralenticular fluid accumulation and the yellow arrow denoting the cataractous area. D- B-mode ocular ultrasound image obtained using an eL18-4 probe (51 Hz) with a depth setting of 2.5 cm, demonstrating a swollen lens. The lens thickness was measured at 9.16 mm (vertical) and 11.0 mm (horizontal), exceeding the typical lens thickness reported in small dogs (6.0-7.0 mm). [A calibrated 2-mm scale bar (lower right) is included for reference].

Given the preoperative diagnosis of an intumescent cataract and the presence of a narrowed iridocorneal angle, postoperative UBM[6] was performed to assess anterior segment configuration. Postoperative UBM[6] demonstrated posterior repositioning of the iris and anterior displacement of the ciliary body following lens removal and capsular tension ring placement (Figure 2B). At this stage, no iris bombé or definite angle closure was observed.

At POD 14, inflammation partially improved (flare 2+, AC cells 2+), and a zonular fiber was observed protruding anteriorly and contacting the corneal endothelium at the 5 o'clock position (Figure 3A). The mydriatic 0.5% tropicamide-0.5% phenylephrine[18] was prescribed; however, adequate mydriasis was not achieved.

At postoperative month (POM) 1, partial posterior synechiae were present except between 2-5 o'clock. Because traction persisted, 0.8 units of intracameral tissue plasminogen activator (tPA)[19] were injected. However, the zonular adhesion remained unchanged.

At POM 2, slit-lamp biomicroscopy3 examination revealed nearly 360° posterior synechiae. Despite this, IOP remained low-normal (7 mmHg), and the iris remained flat without iris bombé, suggesting an alternative drainage route. To further investigate this discrepancy, an additional UBM[6] evaluation was planned.

At POM 4-6, IOP remained 7 mmHg, and AC inflammation gradually improved (flare trace and AC cells 1+). Posterior synechiae persisted, and central-superior corneal lipid deposition developed at POM 5, presumed to result from long-term steroid use (Figure 3B); Medication was adjusted accordingly. By POM 6, the eye remained comfortable with preserved visual function and no glaucoma or retinal complications.

To clarify the route of aqueous outflow, UBM[4] was performed in 12-6, 3-9, and 5-11 o'clock orientations using cross-sectional sulcus-to-sulcus mode images perpendicular to the limbus with the probe centered on the corneal apex. Posterior synechia was absent only at the 5 o'clock zonular region, with firm iris-anterior lens capsule attachment observed elsewhere (Figure 4). Therefore, the zonular fiber was considered to contribute to aqueous humor outflow on UBM[6], and zonular excision was not performed.

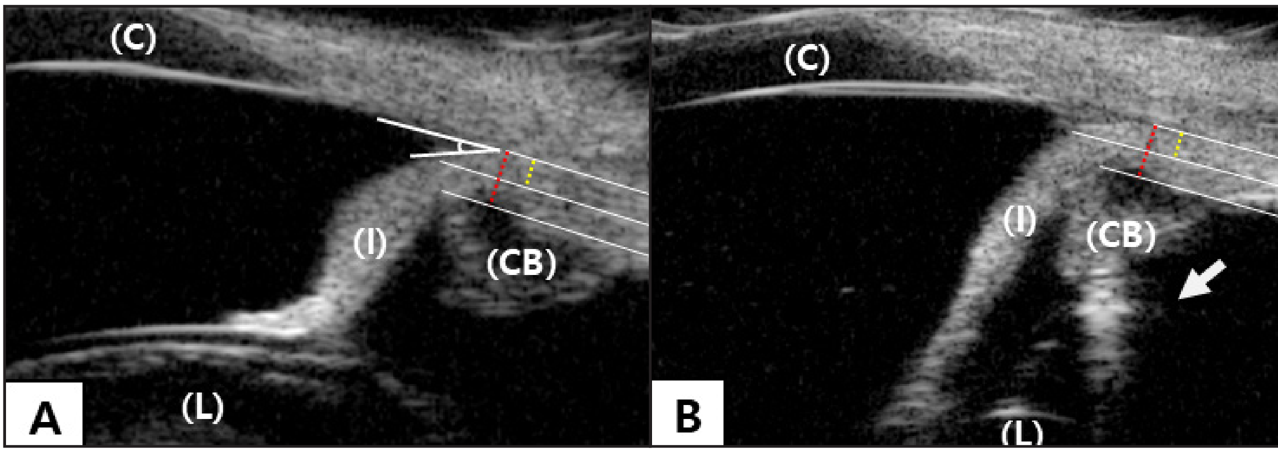

Figure 2. Ultrasound biomicroscopy (UBM) images of the anterior segment with ciliary muscle thickness (CMT) measurements. A- Preoperative high-resolution UBM image (11 o'clock vertical scan) demonstrating narrowing of the iridocorneal angle caused by lens intumescence. Yellow and red dashed lines indicate the measurement axes for the longitudinal fiber ciliary muscle thickness (Lf-CMT) and the combined longitudinal and radial fiber ciliary muscle thickness (LRf-CMT), respectively. Lf-CMT was measured by defining a reference line along the inner scleral surface at the angle recess and placing a parallel line originating from the point where the inner surface of the iris root inserts, thereby representing the thickness of the longitudinal ciliary muscle fibers. LRf-CMT was assessed using the same inner scleral reference line, with a parallel line positioned from the point where the outer surface of the iris root transitions to the anterior contour of the ciliary body, capturing the combined thickness of the longitudinal and radial muscle fibers. B- Postoperative (POM 3) UBM image (11 o'clock vertical scan) showing posterior repositioning of the iris and anterior displacement of the ciliary body associated with the capsular tension ring (CTR), indicated by the white arrow. As in panel A, yellow and red dashed lines denote the Lf-CMT and LRf-CMT measurement axes based on the same anatomical landmarks. Anatomical structures are labeled as cornea (C), ciliary body (CB), iris (I), and lens (L) in both panels.

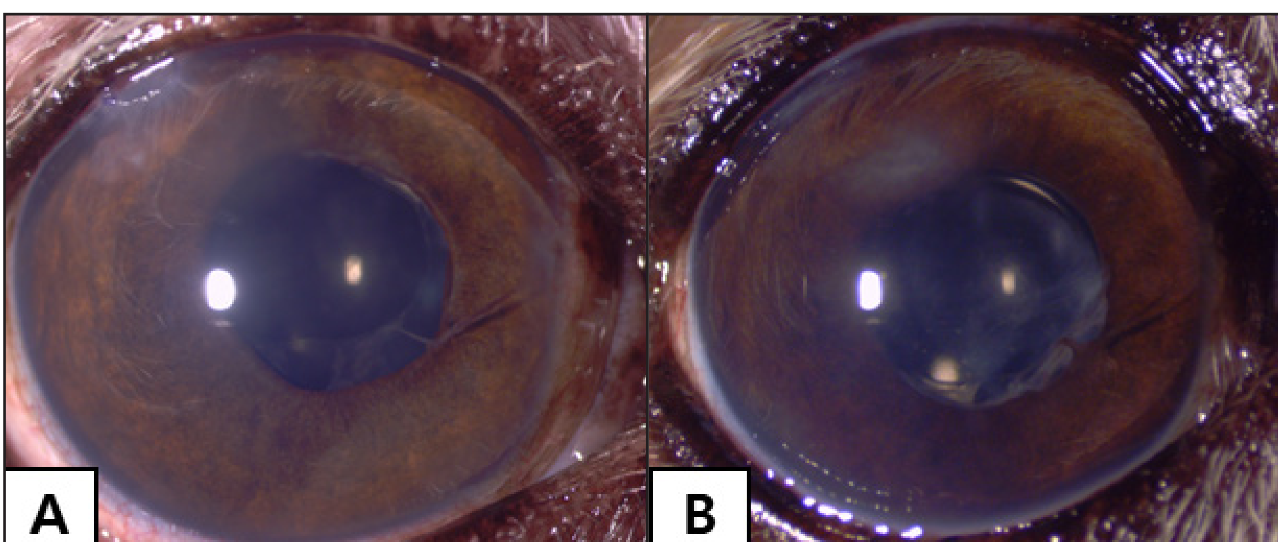

Figure 3. Sequential postoperative slit-lamp images of the right eye (OD). A- POD 14: Diffuse slit-lamp image (x10) showing improved corneal clarity and uveitis, with a clear CCC margin and posterior synechia at 12 o'clock. A zonular fiber connects the iris and corneal endothelium at 5 o'clock. B- POM 5: Corneal edema has completely resolved, and a superior-central lipid deposition is observed on the cornea. Intraocular inflammation is minimal, and the iris maintains a planar configuration. The zonular fiber at the 5 o'clock position remains evident.

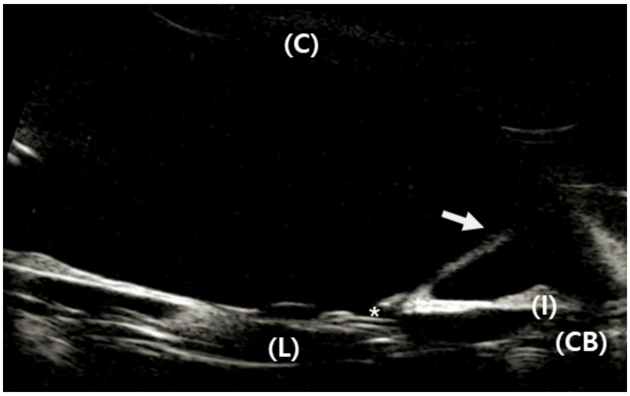

Figure 4. Representative ultrasound biomicroscopy (UBM) cross-sectional images. Cross-sectional views at 5-11 o'clock show the anterior chamber (AC), cornea (C), ciliary body (CB), iris (I), and lens (L). At 11 o'clock, the posterior iris adheres to the anterior capsule. At 5 o'clock, a hyperechoic line connecting the iris to the corneal endothelium (zonular fiber) is indicated by a white arrow. In contrast, a hypo-echoic gap between the posterior iris and the anterior capsule is marked with an asterisk (*), suggesting a potential aqueous flow pathway.

DISCUSSION

This case presented a rare postoperative finding in a bitch which maintained a low-normal IOP and a flat iris contour despite nearly 360° posterior synechiae following phacoemulsification. In standard pathophysiology, complete posterior synechiae restricts aqueous humor flow, leading to pupillary block and iris bombé [5,11]. However, clinical examination in this patient revealed no signs of these complications, suggesting the presence of a hidden aqueous outflow pathway.

UBM imaging provided anatomical insight into this discrepancy. At the 5 o'clock position, a single zonular fiber was observed maintaining a focal separation between the iris and anterior lens capsule. This localized gap appeared to prevent complete synechial fusion, allowing partial aqueous drainage. This anatomical feature may explain the unexpectedly stable IOP and flat iris profile seen on examination. To the authors' knowledge, this is the 1st veterinary report in which UBM suggests that a single zonular fiber may function as a mechanical spacer under extensive synechial conditions.

One important differential diagnosis for the maintenance of normal intraocular pressure, aside from the presence of the zonular fiber, was uveitic hypotony resulting from ciliary body dysfunction. While acute uveitis may transiently reduce IOP through decreased aqueous production and increased uveoscleral outflow, chronic inflammation may lead to structural atrophy of the ciliary body and sustained hypotony [19]. In previous UBM-based studies, ciliary body atrophy has been assessed either by evaluating a reduction in the volume or structural collapse of the ciliary processes, or by quantitatively measuring ciliary muscle thickness (CMT) to identify structural changes [2,3,6,13,21].

At postoperative month 3, the ciliary processes appeared well preserved on UBM, and no structural features suggestive of ciliary body atrophy were observed. CMT was assessed at 2 anatomical locations: the longitudinal fibers (Lf-CMT) and the combined longitudinal and radial fibers (LRf-CMT). Both measurements remained stable compared with preoperative values, with Lf-CMT showing only a minimal change from 0.23 mm to 0.24 mm and LRf-CMT from 0.41 mm to 0.42 mm. These findings indicate that the ciliary body showed no evidence of chronic inflammatory damage or atrophy.

Therefore, the likelihood of chronic uveitis-induced hypotony in this patient appears low. Despite extensive posterior synechia, the focal zonular gap may have served as a hidden outflow pathway, potentially contributing to the maintenance of normal IOP.

Unlike vitreous wick syndrome (VWS) described in human ophthalmology, the zonular fiber observed in this case may have contributed to IOP stability by maintaining partial aqueous outflow. VWS involves an anteriorly herniated vitreous that physically obstructs the pupil or surgical wound, thereby impairing aqueous humor drainage and resulting in pupillary block, iris bombé, and secondary glaucoma [17]. Both VWS and the zonular displacement observed in this case suggest that anteriorly displaced intraocular structures may influence aqueous humor dynamics. However, unlike vitreous, a soft, gelatinous tissue capable of sealing central flow pathways, the zonular fiber in this case was a thin, fixed structure that may have acted as a mechanical spacer, potentially preventing complete synechial adhesion and preserving a focal drainage route.

Typically, intraocular structures protruding into the anterior chamber, such as prolapsed vitreous or foreign material, are surgically removed due to their potential to induce pupillary block or glaucoma [4,8,9]. However, in this case, the zonular fiber appeared to contribute positively to IOP regulation, and the patient exhibited no signs of discomfort or ocular hypertension. Thus, no excision was performed. This highlights how UBM can assist with functional rather than purely structural assessment, facilitating conservative management when appropriate.

UBM has been widely utilized in human ophthalmology to investigate anatomical causes of pseudophakic glaucoma [1,15,18]. Ragab *et al*. [15] used UBM to evaluate 29 human cases and visualized structural abnormalities, including angle closure, IOL haptic malposition, and Soemmering's ring. In contrast, to the authors' knowledge, comparable reports in veterinary ophthalmology remain scarce. This case may therefore represent an anatomical exception in dogs and highlights the value of UBM for detecting subtle structural contributors to aqueous humor dynamics.

Furthermore, this case reinforces the physiological relevance of UBM as a diagnostic modality. Although slit-lamp examination showed extensive posterior synechiae, IOP remained stable. When clinical findings and imaging results diverge, UBM provides essential insight into hidden outflow pathways or preserved ciliary anatomy. These detailed images may help avoid unnecessary interventions, such as synechiolysis, iridectomy, zonulectomy or early aqueous shunting, and support a more conservative, evidence-based treatment approach.

Despite these insights, interpretation is inherently limited by the single-case nature of this report. UBM imaging was performed at specific clock-hour positions rather than circumferentially, and thus, additional aqueous outflow pathways in unscanned regions could not be completely ruled out. Furthermore, the hypothesized function of the zonular fiber in facilitating aqueous outflow is based on anatomical correlation rather than direct physiological measurement. Future studies with functional imaging or flow analysis may further clarify the mechanistic role of such structures.

In conclusion, this case highlights that even a single zonular fiber can create a focal passage for aqueous humor, potentially preventing pupillary block and contributing to the maintenance of IOP despite extensive posterior synechiae. Such subtle features may be overlooked on conventional examination but can be clearly visualized with UBM, which played a key role in this case.

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