CASE REPORT

Anterior Segment Optical Coherence Tomography-Assisted Surgical Planning for Removal of a Corneal Foreign Body: A Case Report and Literature Review

Planification chirurgicale assistée par tomographie à cohérence optique du segment antérieur pour l'extraction d'un corps étranger intracornéen: Un cas clinique avec revue de la littérature

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Abstract

Introduction: Corneal foreign bodies account for nearly one-third of all eye injuries and are a common emergency in ophthalmology. While many cases are straightforward, involving clear diagnosis and treatment, some present significant challenges due to the complexity of the foreign body involved.

Observation: A 20-year-old male presented with discomfort in his right eye following an accident while cutting a tree without wearing protective eyewear. Examination using slit-lamp biomicroscopy revealed a reed foreign body embedded in the cornea. Anterior Segment Optical Coherence Tomography (AS-OCT) provided detailed images, showing the foreign body embedded 300 µm beneath the corneal epithelium but not affecting deeper layers. The foreign body was surgically removed under topical anesthesia, followed by thorough cleansing and suturing of the wound.

Conclusion: AS-OCT is invaluable in the diagnosis and management of complex corneal foreign bodies, enabling precise treatment planning and successful outcomes, as demonstrated in this case.

Key words: Corneal injuries, Eye injuries, Multimodal imaging, Ocular foreign body, Optical coherence tomography

Résumé

Introduction: Les corps étrangers cornéens représentent une urgence courante en ophtalmologie. Bien que de nombreux cas soient simples, impliquant un diagnostic et un traitement clair, certains présentent des défis significatifs en raison de la complexité du corps étranger impliqué.

Observation: Un homme de 20 ans a présenté un inconfort dans son œil droit suite à un accident survenu en coupant un arbre sans porter de lunettes de protection. L'examen à la lampe à fente a révélé un corps étranger végétal incrusté dans la cornée. La tomographie à cohérence optique du segment antérieur a objectivé un corps étranger incrusté à 300 µm sous l'épithélium cornéen respectant les couches les plus profondes. Le corps étranger a été chirurgicalement retiré par voie antérieure sous anesthésie topique, avec suture de la porte d'entrée du corps étranger.

Conclusion: La tomographie à cohérence optique du segment antérieur est inestimable dans le diagnostic et la gestion des corps étrangers cornéens complexes, permettant une planification précise de l'approche thérapeutique, comme démontré dans ce cas.

Mots clés: Corps étranger oculaire, Imagerie multimodale, Lésions cornéennes, Lésions oculaires, Tomographie par cohérence optique

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LA TUNISIE MEDICALE-2024; Vol 102 (11): 955-959

DOI: 10.62438/tunismed.v102i11.5209

Introduction

Corneal foreign bodies (CFB) represent a major type of ocular trauma, accounting for approximately 30.8% of all eye injuries, making them the second most common cause (1). They are a frequent reason for emergency interventions in ophthalmology departments worldwide. Despite the general ease of diagnosing and managing corneal foreign bodies through history taking and slit-lamp examination, certain cases present unique challenges in diagnosis and determining the most appropriate removal method (1).
Anterior-segment optical coherence tomography (AS-OCT) has proven to be invaluable in these scenarios (2). It provides high-resolution, cross-sectional images of the CFB and is particularly useful as a non-contact method that minimizes discomfort in trauma patients (2). This tool is crucial not only for early diagnosis but also for monitoring the progress of treatment in ocular trauma cases (3). Consequently, management strategies for deeply embedded corneal foreign bodies vary based on factors like size, depth, the material involved, and the corneal response (4). Recognizing the distinct characteristics of various materials, as revealed by AS-OCT, can aid clinicians in making informed decisions about the most appropriate treatment approaches (5). This report detailed the diagnosis, management, and follow-up of a patient who presented with a reed foreign body embedded in the cornea. In addition, a brief review of literature was done.

Observations

A 20-year-old male arrived at the emergency department complaining of a foreign body sensation in his right eye. Two hours earlier, he was cutting a tree without protective eyewear when he felt something enter his eye.
Slit-lamp biomicroscopy of the right eye revealed a reed foreign body (FB) embedded in the cornea, with less than one mm protruding at the entry point. The anterior chamber was clear, showing no flare or cells. Both pupils appeared round, regular, and reacted equally to light. The lens was clear. Examination of the left eye and fundoscopic evaluations of both eyes showed no abnormalities.
AS-OCT was utilized to assess the position and dimensions of the FB. The examination revealed that the FB was embedded 300 µm beneath the corneal epithelium within the stroma, measuring between 50 and 60 µm in thickness. The corneal endothelium was intact, indicating no deeper penetration. Additionally, the anterior chamber angle appeared normal, confirming that the surrounding ocular structures were unaffected (Figure 1).

After obtaining informed consent, the patient was taken to the operating room for the removal of the FB under topical anesthesia. During the operation, the FB was successfully removed using surgical forceps. Following removal, the wound was thoroughly washed with povidone-iodine. The entry wound was then carefully sutured using 10-0 monofilament to ensure proper closure and healing.
Postoperatively, the patient started a treatment regimen that included topical antibiotics, artificial tears, and ointment to facilitate healing and prevent infection. One week after the procedure, the patient showed no symptoms, had a visual acuity of 20/20, and the cornea had healed completely without any scarring, indicating a successful recovery (Figure 2).

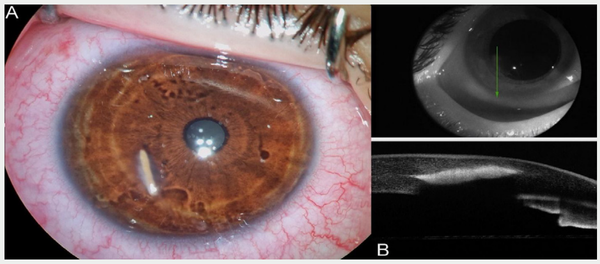

Figure 1. A) Clinical photograph of the patient at presentation showing a foreign body embedded in the cornea of the right eye. B) Anterior segment optical coherence tomography image demonstrating a hyper-reflective lesion. The scans confirm that the foreign body did not fully perforate the cornea, as the endothelium remains intact.

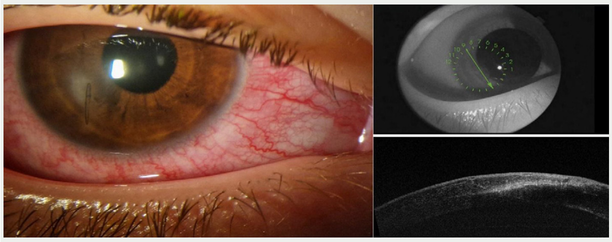

Figure 2. A) A slit-lamp photograph displaying nicely aligned wound edges with minimal stromal edema. B) Anterior segment optical coherence tomography scan illustrating the integrity of the cornea, with edema along the wound edges and slight scarring in the stroma. This is represented by hyperreflectivity within the stromal layers.

The use of AS-OCT provided critical insights into the management of a deeply embedded CFB, revealing its specific characteristics and enabling precise surgical planning. Our case study highlights the effectiveness of AS-OCT in identifying the exact position, size, and depth of the FB. This imaging allowed us to plan a precise and minimally invasive surgical approach, contributing to a successful outcome and rapid patient recovery.
CFB is a frequent emergency in ophthalmology (1). Patients presenting with a CFB typically report a range of symptoms such as redness, a sensation of something in the eye, irritation, tearing, pain, and blurred vision (6). Prompt and correct removal of the FB is crucial (7). While the diagnosis and management of CFBs are usually straightforward, relying on patient history and slit-lamp examination, some atypical FB cases can complicate both diagnosis and the selection of an appropriate removal technique, due to the diverse nature of the FBs (8).
In clinical practice, the cornea is commonly examined using slit-lamp biomicroscopy, typically at magnifications ranging from 10× to 25×, and sometimes up to 100× (2). However, evaluating a corneal or anterior chamber FB using standard slit-lamp examination can be challenging, particularly when the FB is transparent or embedded within a corneal opacity, or is located in a bloody anterior

chamber (5). Under such conditions, there is a risk that the FB might be missed (9). The assessment of the depth and size of transparent materials can be particularly problematic (10). Additionally, small CFB can be difficult to detect in areas with corneal opacities, as they might be easily overlooked during clinical examinations (11).

In cases of ocular trauma, additional diagnostic tools such as AS-OCT or Ultrasound Biomicroscopy are often necessary (5). AS-OCT is particularly useful for diagnosing ocular surface injuries and monitoring the healing process post-surgery (3). It can also uncover lesions that are not visible or difficult to detect during a routine slit-lamp examination (3).

Spectral-Domain OCT offers significant benefits as it is a non-contact method that causes minimal discomfort to trauma patients. It allows for the acquisition of high-resolution cross-sectional images of the anterior segment, including the cornea (5). AS-OCT enables rapid, non-invasive imaging of ocular tissues at various depths, providing a precise evaluation of foreign body characteristics (2).

The use of AS-OCT in planning the removal of intra-corneal FBs presents specific challenges and limitations (4). These include accurately determining the size, position, and penetration depth of the FB (5). FB composed of different materials exhibit distinct optical penetration properties and OCT characteristics, which can result in varying imaging artifacts, as noted by Armarnik et al. (5).

Materials such as pencil graphite, metals, and wood typically display a hyper-reflective anterior border (12). However, imaging the posterior border can be problematic due to shadowing effects (12). Wood appears as a hyper-reflective mass, with the degree of penetrability varying based on the material's concentration (4). Pencil graphite and metals might produce a mirroring effect that complicates assessing the depth of penetration (4). Transparent materials like glass or plastic show hyper-reflective sharp borders when surrounded by air or fluid, but their imaging can be challenging when embedded purely within the corneal stroma (4).

In cases where the composition of the FB is unknown, these OCT characteristics can be critical in distinguishing the materials involved and aiding decision-making regarding the necessity and urgency of removal (5). Goel et al. (13), Akbaş et al. (14), and Wang et al. (12) have also published studies utilizing AS-OCT to describe the characteristics of various CFBs and their respective OCT findings. We conducted a literature search on PubMed for relevant articles. Table 1 lists various studies on different CFBs evaluated by AS-OCT, summarizing the findings of the main similar case reports.

Wang's study offers a structured approach to utilizing AS-OCT for diagnosing CFB (12). Based on the findings, the diagnostic criteria for CFB using AS-OCT can be outlined as follows:

- (i) Eye injury history
- (ii) The consistency of the corneal layers being broken
- (iii) High or low signals with clear boundaries
- (iv) High or low signals with blurred boundaries
- (v) Lesions associated with central or marginal zone shadowing effect

According to these criteria:

- A diagnosis of CFB is confirmed if conditions (i), (ii), (iii), and (v) are met.
- A CFB is highly suspected if conditions (i), (i), (iv), and (v) are fulfilled.
- Caution is advised in diagnosing a CFB when only conditions (i) and (ii) are met, along with a high signal with blurred boundaries, but without condition (v). In such cases, alternative diagnoses such as local inflammation, corneal scarring or neoplasm should be investigated (16).

In our case, the use of AS-OCT proved invaluable. The preoperative AS-OCT revealed that the FB had not completely perforated the cornea—a detail that was not clearly discernible with slit-lamp biomicroscopy. This imaging allowed us to precisely determine the location, size, and depth of the CFB. We could also assess the condition of the surrounding ocular structures and strategically plan the most appropriate surgical approach, including whether sutures were necessary. With the detailed information provided by AS-OCT, we were able to avoid open globe surgery.

AS-OCT plays a vital role in providing essential information about the integrity of Descemet's membrane and the exact point of entry of the foreign body (5). This information is pivotal for planning the surgical removal (17). If Descemet's membrane is intact and the scar at the point of entry is visible, the FB can be removed via the anterior route (2). Conversely, if Descemet's membrane is breached and the entry point has healed, the FB is removed through the anterior chamber using an air tamponade (2). This latter approach does not require sutures, thereby minimizing the risk of inducing any astigmatic effects (2).

In the presented case the removal process was straightforward, we were able to grasp the FB by its protruding posterior edge and extract it through its original entry route. AS-OCT showed that the FB was partially embedded, with its posterior edge accessible from the corneal surface. This allowed for a simpler and less invasive removal method, directly addressing the specific conditions of the injury.

In situations where corneal thinning is a concern after the removal of a foreign body, AS-OCT proves highly beneficial (18). It allows for a quantitative evaluation of the remaining corneal thickness and can help identify any risk of imminent corneal perforation. This precise measurement is crucial in planning further protective or corrective measures (2). In the case discussed, the patient was fortunate that the FB did not completely penetrate the cornea, and there was no significant tissue loss. However, in instances where there is corneal tissue loss, management strategies need to be adjusted (2). According to Vote and Elder (19), if the corneal defect is smaller than two mm, treatment can involve the application of cyanoacrylate glue to seal the defect and the use of a bandage contact lens to protect the area during healing.

Table 1. Summary of main similar case reports on different corneal foreign bodies (CFBs) evaluated by Anterior segment optical coherence tomography (AS-OCT).

1st author (reference)	Eye affected	Sex	Age	Initial VA	Type of FB	AS-OCT	Management	Final VA
Bhargava et al. (4)	RE	M	30-year-old	20/60	Metallic	FB had penetrated LASIK flap and lodged into midstroma, 207 µm deep.	FB removed with 26G needle in operation theatre with the application of cyanoacrylate glue and bandage contact lens.	20/20
Goel et al. (13)	LE	M	24-year-old	20/20	Metallic	Shadowing in the corneal layers at the location of the FB. Hyper-reflective lesion in the AC behind the cornea, indicating that the FB had fully penetrated the cornea and extended into the AC.	A paracentesis was performed to fill the AC with viscoelastic, and end-grasping intraocular forceps were used to carefully remove the FB. The AC was then washed, and the eye was closed with a tight bandage.	20/20
Volek et al. (8)	RE	M	37-year-old	20/25	Reed FB	FB 192–299 µm deep from the corneal epithelium in the stroma, with 53–80 µm of thickness. The corneal endothelium was intact.	The FB was removed through an incision made with a LaserEdge 2.85-mm clear corneal knife along the middle axis of the FB. Using surgical forceps, the FB was easily extracted through this incision. Since the wound edges were well-aligned, sutures were not applied.	20/20
Darade et al. (7)	LE	M	27-year-old	20/30	Grass blades	Corneal thickness of approximately 735 µm at the lesion site, with a distance of 122 µm from the epithelium to the FBs.	The FB tracts were carefully exposed using a 26-gauge needle. The loosened FBs were then removed with a McPherson forceps, ensuring the cornea was not perforated.	20/20
Celebi et al. (2)	LE	M	34-year-old	20/20	Metallic	Shadowing in the corneal layers at the location of the FB. A hyper-reflective lesion near the inside edge of the FB in the cornea, indicating that the FB had not fully penetrated the cornea.	The FB was removed via the external route, as it had not completely penetrated the cornea	20/20
Al-Ghadeer et al. (15)	RE	M	19-year-old	20/30	Glass	Image of the intrastromal glass in the RE, showing both localized and measured multiple glass fragments in a single scan.	Clinical monitoring without surgical intervention.	VA un-changed
Our study	RE	M	20-year-old	20/30	Reed FB	FB was embedded 300 µm beneath the corneal epithelium within the stroma, measuring between 50 and 60 µm in thickness. The corneal endothelium was intact,	FB successfully removed using surgical forceps. The entry wound was then carefully sutured using 10-0 monofilament	20/20

AC: Anterior chamber, **FB**: Foreign body, **LE**: Left eye, **RE**: Right eye, **M**: Male, **VA**: Visual acuity.

This approach helps stabilize the cornea, prevents further damage, and promotes tissue recovery, offering an effective method to manage minor corneal injuries.

Our study has certain limitations that warrant consideration. As a single case report, the findings are specific to this particular instance and may not reflect all cases of CFBs. Future studies involving larger sample sizes or multiple case reports would be beneficial to further validate these findings. Additionally, this paper does not compare the outcomes of AS-OCT-assisted surgery with traditional methods. Future research including such comparisons could provide additional insights into the advantages of AS-OCT. Further technical details about the AS-OCT imaging process and interpretation could enhance understanding for readers less familiar with this technology. The follow-up period in this report is relatively short; extended follow-up periods would offer more comprehensive information on the long-term durability of the surgical outcome and potential late-onset complications. Incorporating the patient's perspective on the comfort and experience of the AS-OCT-assisted procedure could provide valuable context. Finally, while the report focuses on a specific type of FB (reed), further research is needed to determine the applicability of these findings to other types of CFBs with different optical and physical properties.

Conclusion

AS-OCT is indeed a non-invasive, rapid imaging tool that is invaluable for examining ocular tissues at various depths. Its ability to accurately locate FBs and assess the condition of surrounding ocular structures is essential for preoperative surgical planning. This can also prevent any intra or postoperative refractive surprises thus providing the best possible outcomes.

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