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Improved intraocular foreign body localization using orbital computed tomography data

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Background: *Detection and localization of an intraocular foreign body (IOFB) are essential for assessing the severity of injury and selecting an appropriate method for IOFB removal.*

Purpose: *To improve the method of IOFB localization through the use of the Komberg-Baltin prosthesis while performing orbital computed tomography (CT) scans.*

Material and Methods: *We reviewed the medical records of 6 patients with a penetrating corneal and/or scleral injury and an IOFB in the posterior segment. Patients had ultrasonography of the ocular anterior and posterior segments and Komberg-Baltin prosthesis-assisted CT of the orbit as per our method reported previously to verify the location of the IOFB. Orbital radiography was performed at the point of care. The results of radiography, ultrasonography and CT for each case were reviewed and compared. The final verification of IOFB location was performed preoperatively during a standard three-port 25-G pars plana vitrectomy with IOFB removal.*

Results: *In 3 cases, intraoperative visualization during vitrectomy confirmed the results of preoperative IOFB imaging (radiography, ultrasonography and orbital CT). In these cases, an IOFB was a metallic fragment measuring 0.9 to 2.5 mm. In one case, a metallic IOFB was found by ultrasonography, but not by radiography. CT, when performed by our method, found an IOFB measuring 0.2 x 0.3 mm preretinally. In a patient with an IOFB (a wire measuring 10.0 x 1.0 mm, at 20 mm from the anatomical axis, and 9-11.5 mm from the limbal plane) and local retinal detachment, there was a discrepance between the foreign body location indentified by radiography and that identified by CT with the use of the Komberg-Baltin prosthesis. Large differences in the distance between the IOFB and the limbal plane and between the IOFB and the anatomical axis (4 mm and 5 mm, respectively) were caused by the mobility of the foreign body located beneath the retina.*

Conclusion: *Localizing an IOFB using Komberg-Baltin prosthesis-assisted CT is advantageous to radiography due to an opportunity for accurate localization of a mobile IOFB with a patient in the position as similar as possible to his position during IOFB removal surgery (i.e., the supine position).*

Keywords:

penetrating eye injury, intraocular foreign body, diagnostic imaging, computed tomography

Introduction

A traumatic ocular injury with a foreign body lodged in the orbit is one of the most common types of ocular trauma and is a serious medical and social concern. Intraocular foreign bodies (IOFBs) account for 18 to 41% of all open globe injuries (OGIs) [1]. In a cross-sectional study of US nationwide emergency department data, OGIs with a “foreign body entering the eye” mechanism accounted for as much as 20% of all OGIs among adult age groups [2]. The route of entry for the IOFB is via the cornea in 70% of cases [3] and most IOFBs will come to rest in the posterior segment [4].

Direct damage due to injury and sequelae of the retained IOFB are the major causative factors of the failure of treatment for IOFB-related OGIs.

Traumatic endophthalmitis and retinal detachment (RD) are among the vision-threatening sequelae, occurring in 2% to 30% and 5.5% to 30%, respectively, in OGIs with IOFBs [5], which is more frequently than in OGIs without IOFBs.

Detection and localization of the IOFBs are essential for assessing the severity of injury and selecting an appropriate method for IOFB removal. Baltin and Komberg’s method for roentgenological localization of IOFB consists in performing X-rays with a special prosthesis put on the globe to make the limbus and corneal principal meridians radiographically opacified, and using special templates to measure the distance on the X-ray film between the IOFB and the prosthesis [6]. This easy-to-perform method has, however, some shortcomings. Particularly, it (1) does not allow detecting IOFBs smaller than 0.5 mm in size and (2) does not take into account possible changes in the location of a mobile IOFB when a patient has either his X-ray examination in the standard radiographic position with his face down or his surgery lying supine.

Unlike Baltin and Komberg's method, computed tomography (CT) is a modern and informative technique for detecting metallic and non-metallic IOFBs of various sizes and intraocular locations.

CT is very sensitive for detecting metallic IOFBs even smaller than 0.3 mm in size not only in the ocular surface structures, but also in the deep intraocular structures and orbital structures. In addition, unlike plain radiography, helical CT has been found to be very sensitive for detecting small glass IOFBs, with 1.5-mm glass fragments detected at a rate as high as 96.2% [7]. Although CT has a high diagnostic value in IOFB detection, no standards are available for the interpretation of the results of CT scan (e.g., the determination of foreign body‘s location with respect to the limbal plane and anatomical axis of the eye).

Given the above, the purpose of this study was to improve the method of IOFB localization through the use of the Komberg-Baltin prosthesis while performing orbital CT scans.

Material and Methods

We reviewed the medical records of 6 patients with a monocular eye injury who have been treated on in-patient basis at Post-Traumatic Eye Pathology Department of the Filatov Institute of Eye Diseases and Tissue Therapy. All these patients were males, with an age ranging from 27 to 53 years, and with a penetrating corneal and/or scleral injury and an IOFB in the posterior segment. Of the 6 patients, 4 received initial surgical debridement at the point of primary care, and were hospitalized for the surgical treatment and removal of an IOFB in the early period (≤ 7 days) after the traumatic event. In addition, a patient without signs of corneal scarring but with signs of siderosis reported on a traumatic event that had occured to him about 10 months prior to his hospitalization. Moreover, a patient with the intraocular lens (IOL) had a traumatic corneoscleral scar due to the penetrating injury he acquired more than 20 years prior, while being a child.

All patients received an eye examination including visual acuity, perimetry, tonometry, biomicroscopy and ophthalmoscopy. Orbital radiography was performed at the point of primary care. At the institute, all patients had ultrasonography of the ocular anterior and posterior segments and orbital CT to verify the location of the IOFB.

This study followed the ethical standards stated in the Declaration of Helsinki and informed consent was obtained in all patients.

CT scans were acquired on an Aquilion Prime 160-slice CT scanner (Toshiba Medical Systems, Tokyo, Japan) with the use of the Komberg-Baltin prosthesis as per our method reported previously [8]. In addition, 3D reconstruction of the orbit with retained foreign body was performed. The shape, density, dimensions and exact location of the foreign body in the orbit and in the eye were determined by measuring the distance on CT scans between the IOFB and anatomical axis of the eye and between the IOFB and the limbal plane radiographically opacified through the use of the Komberg-Baltin prosthesis. CT image data were transferred to Vitrea workstation for postprocessing.

The results of radiography, ultrasonography and CT for each case were reviewed and compared. A standard three-port 25-G pars plana vitrectomy with IOFB removal was performed in all cases. The final verification of IOFB location was performed intraoperatively. The diagnostic value of the used preoperative diagnostic methods was assessed based on the correspondence between examination results and the actual location of the foreign body in the eye.

Descriptive statistical methods were used for statistical analysis.

Results

In 3 cases, intraoperative visualization during vitrectomy confirmed the results of preoperative IOFB imaging (radiography, ultrasonography and orbital CT) with regard to foreign body location and size. In these cases, an IOFB was a metallic fragment measuring 0.9 to 2.5 mm and embedded in the ocular coats, and located either less than 7 mm from the limbus (one case) or more than 7 mm from the limbus (two cases).

In another case, the IOFB was found by ultrasonography, but not by radiography. CT, when performed by our method, found an IOFB measuring 0.2 x 0.3 mm preretinally, 7 mm from the anatomical axis, and 13 mm from the limbal plane.

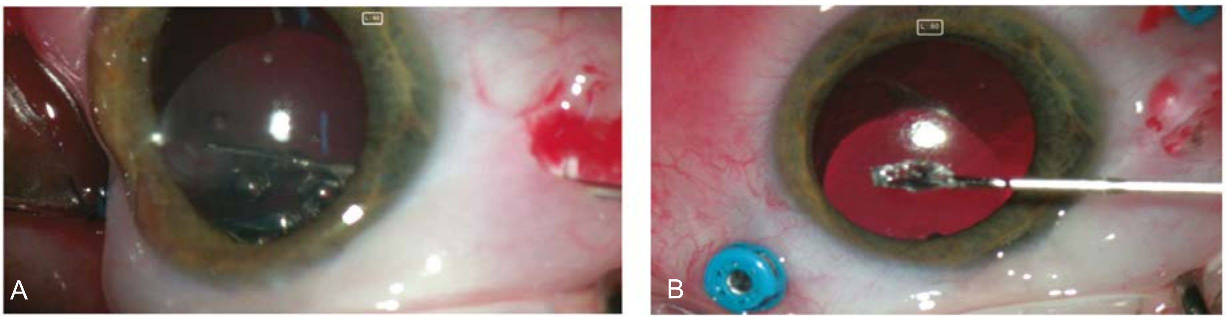

Fig. 1. Intraoperative images of glass IOFB. (A) Exposed IOFB is grasped with forceps on scleral depression in the projection of the IOFB based on CT data. (B) Extracted glass IOFB

The patient with the IOL and a longer than 20-year history of a traumatic event was referred to the institute for recurrent hyphema. Roentgenogram showed no shadow from the foreign body. Ultrasonography found a 2.0×2.5-mm foreign body in the ciliary body projection, in the inferior inner quadrant. CT of the orbit, when performed with the use of the Komberg-Baltin prosthesis, found an IOFB measuring 2.0 × 3.2 mm in the parietal region, at 3 o'clock, 6.5 mm from the anatomical axis, and 4.0 mm from the limbal plane. During vitrectomy, the location of the glass foreign body was in complete agreement with CT interpretation (Fig. 1).

The diagnostic potential of orbital CT with the use of the Komberg-Baltin prosthesis as per our method was particularly vividly demonstrated in the patient who developed local retinal detachment due to a penetrating scleral injury with a metallic foreign body (wire). Ultrasonography found a 9×1-mm foreign body at the equator, in the 5 to 7 o'clock position, subretinally. There was a retinal detachment with a height of 0.8 mm inferiorly, extending to the extreme periphery (Fig. 2). Orbital radiography found an IOFB measuring 10.0 x 1.0 mm, and extending from 5 to 7 o'clock, 10 mm from the anatomical axis, and 9-11.5 mm from the limbal plane (Fig. 3). CT, when performed with the use of the Komberg-Baltin prosthesis, found a concave and horizontally elongated IOFB measuring 10.0 × 1.5 mm, with a density of +1500 HU (metal), extending from 5 to 7 o'clock, 5 mm from the anatomical axis, 15.0 mm from the limbal plane, and 18 mm from the cental cornea (Fig. 4).

Intraoperative imaging findings with regard to the foreign body meridian and shape were in complete agreement with those of preoperative ultrasonography, radiography and CT (Fig. 5). The dimensions of the retrieved wire fragment were identical to those determined with CT. Of note is the discrepancy between the foreign body location identified by radiography and that identified by CT. The difference in the distance between the IOFB and the limbal plane was 4.5 mm, and that between the IOFB and the anatomical axis, 5 mm. These large differences between the location identified by radiography and that identified by CT were caused by the mobility of the foreign body located beneath the retina, which became apparent intraoperatively. It is the mobility of the foreign body that enabled moving it to the retinal entry site and removing it from beneath the retina through the defect present in the retina.

Therefore, incorrect foreign body localization with a routine radiography with the use of the Komberg-Baltin prosthesis was seen in two of the six cases. In six cases of the study, ultrasound imaging findings and findings of Komberg-Baltin prosthesis-assisted orbital CT performed by our method, enabled correct foreign body localization, which was confirmed intraoperatively and contributed to the uncomplicated removal.

Discussion

Investigation of the features of the diagnosis of and approaches to treatment of eye injuries, particularly those associated with IOFBs, is still a challenge for prospective studies, due to variability in the course of these conditions.

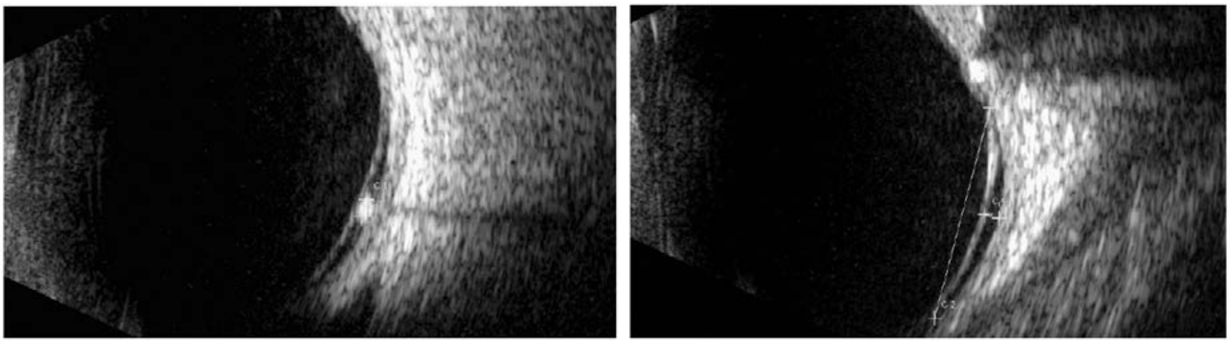

Fig. 2. Ultrasound images of a 32-year-old patient diagnosed with a penetrating scleral wound, IOFB (wire), local retinal detachment and siderosis

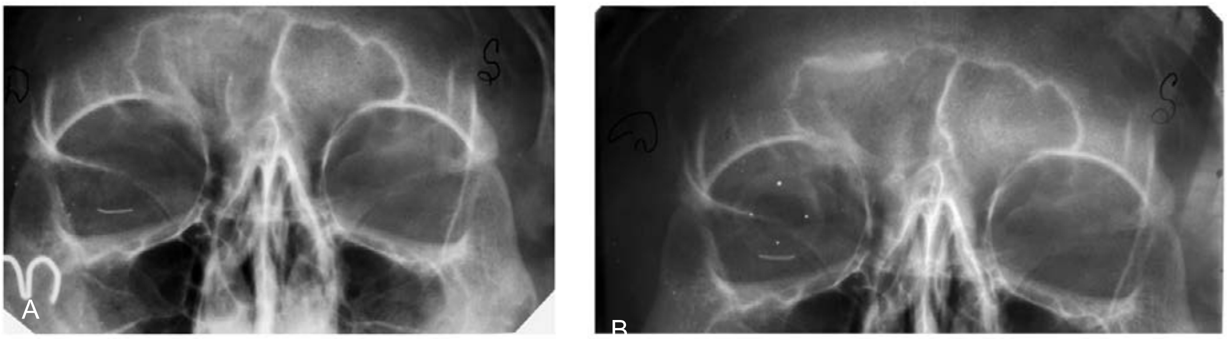

Fig. 3. Frontal orbital radiographs of the same patient obtained at initial examination (A) and taken with the use of the Komberg-Baltin prosthesis (B)

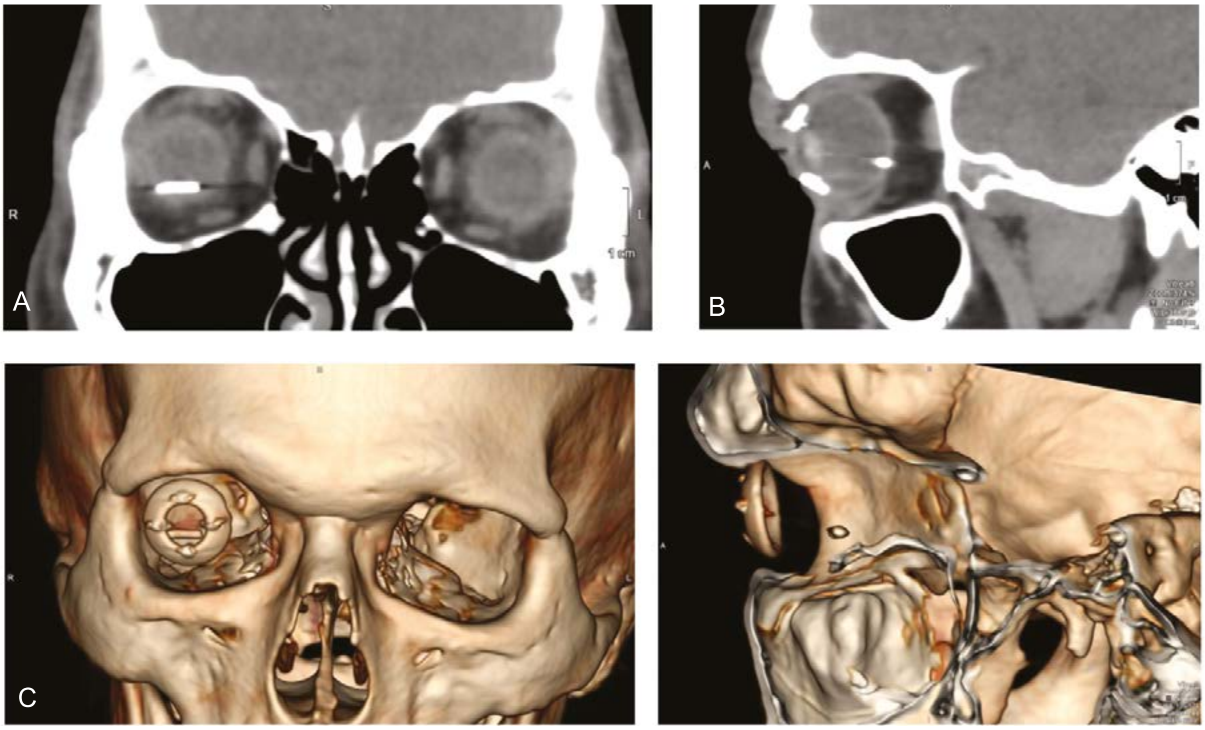

Fig. 4. Orbital computed tomography images for the same patient obtained with a conventional method (A) and with the use of the Komberg-Baltin prosthesis (B), and 3D reconstruction with the Komberg-Baltin prosthesis (C)

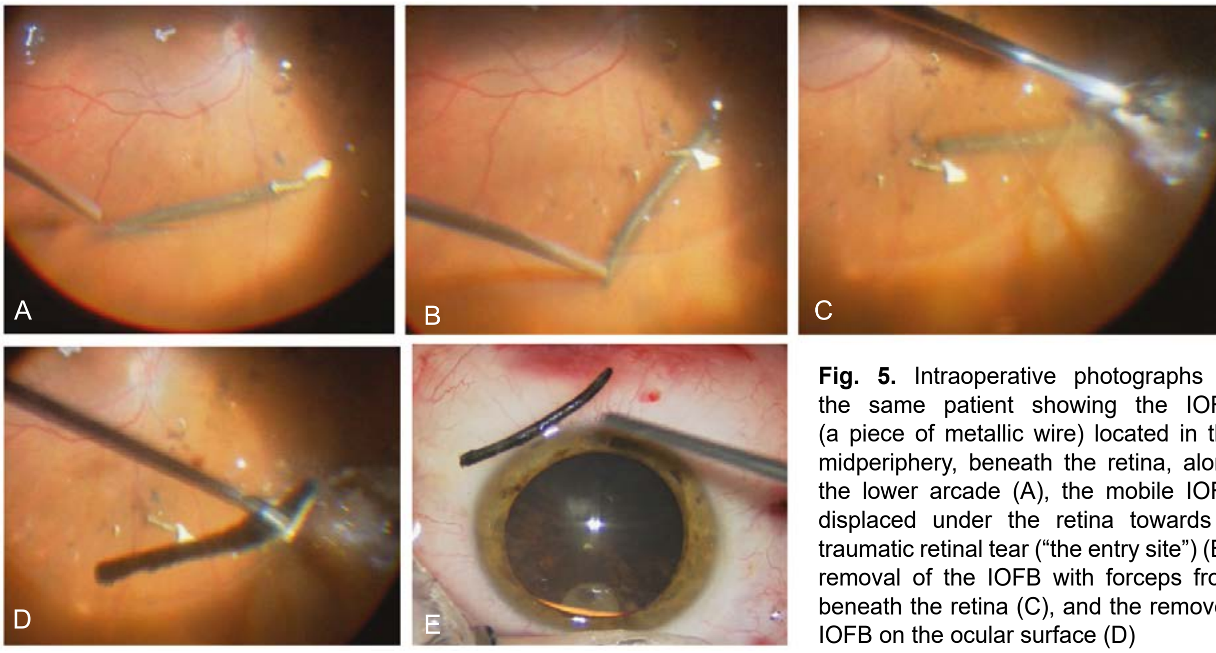

Fig. 5. Intraoperative photographs of the same patient showing the IOFB (a piece of metallic wire) located in the midperiphery, beneath the retina, along the lower arcade (A), the mobile IOFB displaced under the retina towards a traumatic retinal tear ("the entry site") (B), removal of the IOFB with forceps from beneath the retina (C), and the removed IOFB on the ocular surface (D)

A systematic review of the literature on the diagnosis and management of traumatic IOFBs provides a schematic flight plan to assist in clinical decision making when confronted with an IOFB [9]. Imaging methods are crucial for the identification and localization of IOFBs. Multimodal imaging should be considered if IOFB is suspected. If the media are clear, signs of penetrating eye injury and anterior segment IOFBs can be detected by biomicroscopy of the anterior segment. Gonioscopy is required for complete visualization of the angle when an anterior segment IOFB is suspected. Ophthalmoscopy has a limited utility when a posterior segment IOFB is suspected in the presence of vitreous hemorrhage and/or retinal detachment.

Presently, CT is an essential component of diagnostic protocols and treatment strategies for open-globe injury patients with IOFB in many clinical guidelines [10, 11]. CT with 1-mm sections (and no contrast) can detect up to 100% of metallic IOFBs greater than 0.05 mm3 [9].

Helical CT may be superior for smaller metal fragments. Plain films can miss nonmetallic IOFBs up to 60% of the time and are inferior to CT in localizing IOFBs [9].

Ultrasound is more user dependent than CT but can be up to 98% sensitive in detecting IOFBs in the appropriate clinical setting [9]. It is superior to CT in detecting coexistent intraocular pathology [12].

In the current study, we also used multimodal imaging for detecting and localizing IOFBs. Our analysis of the correspondence between preoperative imaging findings and the intraoperative findings of IOFB location found that orbital CT with the use of the Komberg-Baltin prosthesis was the most informative method for IOFB localization. The approach proposed by us for localizing an IOFB is not only advantageous in detecting non-opaque and small IOFBs, but also enables accurate localization of a mobile IOFB when a patient has his surgery lying supine. A posterior segment IOFB, if located in the vitreous or beneath the retina, is mobile irrespective of the patient's position. In this case, the IOFB should be localized by radiography or CT with the patient in the position as similar as possible to his position during IOFB removal surgery (i.e., the supine position).

A routine Komberg-Baltin prosthesis-assisted radiography is performed with a patient lying prone, which will result in incorrect data on the location of a mobile IOFB. Therefore, when detecting and localizing an IOFB, the ophthalmologist should take in account all the features of the mechanism of the IOFB-related injury, the supposed nature and dimensions of the IOFB, and the capacity of the latter for mobility during a change in patient's posture. The clinical application of multimodal imaging using the advanced capabilities of CT (e.g., Komberg-Baltin prosthesis-assisted CT) will enable avoiding errors and determining an adequate surgical strategy with regard to the way and method for IOFB removal.

Conclusion

First, multimodal imaging for detecting and localizing an IOFB using orbital ultrasonography and CT enables accurate foreign body localization and determining the surgical approach and strategy for IOFB removal. Second, localizing an IOFB using Komberg-Baltin prosthesis-assisted CT is advantageous to radiography due to an opportunity for accurate localization of a mobile IOFB with a patient in the position as similar as possible to his position during IOFB removal surgery (i.e., the supine position).

References

1. Mester V, Kuhn F. Intraocular foreign bodies. Ophthalmol Clin North Am. 2002 Jun;15(2):235-42. DOI: 10.1016/s0896-1549(02)00013-5.
2. Mir TA, Canner JK, Zafar S, Srikumaran D, Friedman DS, Woreta FA. Characteristics of open globe injuries in the United States from 2006 to 2014. JAMA Ophthalmol. 2020;138(3):268–75. DOI:10.1001/jamaophthalmol.2019.5823
3. Bourke L, Bourke E, Cullinane A, O'Connell E, Idrees Z. Clinical outcomes and epidemiology of intraocular foreign body injuries in Cork University Hospital, Ireland: an 11-year review. Ir J Med Sci. 2021 Aug;190(3):1225-30. DOI: 10.1007/s11845-020-02443-9. PMID: 33230610.
4. Zhang Y, Zhang M, Jiang C, Qiu HY. Intraocular foreign bodies in china: clinical characteristics, prognostic factors, and visual outcomes in 1,421 eyes. Am J Ophthalmol. 2011 Jul;152(1):66-73.e1. DOI: 10.1016/j.ajo.2011.01.014.
5. Vingopoulos F, Wang Y, Grob S, Li CYL, Eliott D, Kim LA, et al. Open Globe Injury with Intraocular Foreign Body. J Vitreoretin Dis. 2021 Jul 1;5(4):288-294. DOI: 10.1177/2474126420965033.
6. Zhaboiedov GD, Kireiev VV. [Ophthalmology:Training]. Kyiv: Meditsina; 2012. Ukrainian.
7. Gor DM, Kirsch CF, Leen J, Turbin R, Von Hagen S. Radiologic Differentiation of Intraocular Glass: Evaluation of Imaging Techniques, Glass Types, Size, and Effect of Intraocular Hemorrhage. Am J Roentgenology. 2001 Nov;177(5):1199–203.
8. Ulianova NA, Stasiuk IuV, Sidak-Petretska OS, Tychina NP. [Method of the x-ray localization of intraocular foreign bodies]. 116572, 2023.
9. Parke DW 3rd, Flynn HW Jr, Fisher YL. Management of intraocular foreign bodies: a clinical flight plan. Can J Ophthalmol. 2013 Feb;48(1):8-12. DOI: 10.1016/j.jcjo.2012.11.005.
10. Jabłoński M, Winiarczyk M, Biela K, Bieliński P, Jasielska M, Batalia J, et al. Open Globe Injury (OGI) with a Presence of an Intraocular Foreign Body (IOFB)-Epidemiology, Management, and Risk Factors in Long Term Follow-Up. J Clin Med. 2022 Dec 26;12(1):190. DOI: 10.3390/jcm12010190.
11. Jung HC, Lee SY, Yoon CK, Park UC, Heo JW, Lee EK. Intraocular Foreign Body: Diagnostic Protocols and Treatment Strategies in Ocular Trauma Patients. J Clin Med. 2021 Apr 25;10(9):1861. DOI: 10.3390/jcm10091861.
12. Parke DW 3rd, Pathengay A, Flynn HW Jr, Albini T, Schwartz SG. Risk factors for endophthalmitis and retinal detachment with retained intraocular foreign bodies. J Ophthalmol. 2012;2012:758526. doi: 10.1155/2012/758526

Disclosures

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