Clinical features of traumatic macular holes secondary to globe contusion versus those secondary to blast-related ocular trauma

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Клінічні особливості травматичних розривів макули при контузії очного яблука та при мінно-вибуховій травмі ока

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Abstract

Purpose. *To examine the clinical features of traumatic macular holes (TMHs) secondary to globe contusion versus those secondary to blast-related ocular trauma (BROT) based on the review of medical records of patients visiting SI "The Filatov Institute of Eye Diseases and Tissue Therapy of the National Academy of Medical Sciences of Ukraine" in 2018-2025.*

Material and Methods. *We retrospectively reviewed the medical records of 35 patients with TMH who underwent examination and treatment at SI "The Filatov Institute of Eye Diseases and Tissue Therapy of the National Academy of Medical Sciences of Ukraine" in 2018-2025. Patients were divided into two groups based on the mechanism of trauma, with group 1 including 18 patients (18 eyes) with TMHs secondary to a closed-globe injury (namely, globe contusion), and group 2, 17 patients (17 eyes) with TMHs secondary to BROT.*

Results. *We found that TMHs secondary to globe contusion had a smaller size and an oval shape, and may spontaneously close, with better functional outcomes. TMHs secondary to BROT were relatively large and round, and were associated with isolated or multiple choroidal ruptures. The latter TMHs, when accompanied by subfoveally located choroidal ruptures, had lower visual acuity and limited improvement toward closure after surgical treatment. Surgery failed to achieve anatomical hole closure in two patients.*

Conclusion. *There are substantial differences in morphology, course, and visual prognosis of surgery between TMHs secondary to globe contusion and those secondary to BROT. The former are characterized by a more favorable clinical course, whereas the latter are accompanied by more severe ocular lesions, with lower visual function and the conditions creating a challenge in the diagnostic evaluation.*

Keywords: *traumatic macular hole, blast-related trauma, globe contusion, macular hole, optical coherence tomography, vitrectomy, sclopetaria, retina.*

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Резюме

Мета. *Дослідити клінічні особливості травматичних розривів макули (ТРМ) при контузіях очного яблука та при мінно-вибуховій травмі ока на основі звернень пацієнтів до ДУ «Інститут очних хвороб і тканинної терапії ім. В. П. Філатова НАМН України».*

Матеріал та методи*. Проведено ретроспективний аналіз 35 випадків ТРМ у пацієнтів, які проходили обстеження та лікування в ДУ «Інститут очних хвороб і тканинної терапії ім. В. П. Філатова НАМН України». Пацієнти були розподілені на дві групи в залежності від механізму травми. До першої групи було віднесено хворих із ТРМ, що виникли внаслідок закритої травми ока, а саме контузії очного яблука*

(18 очей). До другої групи включили пацієнтів із ТРМ, спричиненими мінно-вибуховою травмою (МВТ) органа зору (17 очей).

Результати. *Встановлено, що ТРМ при контузії очного яблука характеризуються відносно меншими розмірами, овальною формою та можливістю спонтанного закриття з покращенням зорових функцій. При МВТ органа зору ТРМ мають відносно більші розміри, округлу форму, спостерігаються поодинокі або множинні розриви судинної оболонки. При ТРМ внаслідок МВТ, що супроводжуються субфовеолярними розривами судинної оболонки, відзначено нижчі показники гостроти зору та обмежену позитивну динаміку після хірургічного лікування. У частини пацієнтів після хірургічного втручання анатомічного закриття розриву досягти не вдалося.*

Висновки. *ТРМ, спричинені контузією очного яблука, мають суттєві відмінності за морфологією, перебігом та функціональним прогнозом хірургічного лікування порівняно з ТРМ, спричиненими МВТ. Контузійні ушкодження характеризуються більш сприятливим клінічним перебігом, тоді як МВТ супроводжуються більш тяжким ураженням ока, нижчими показниками зорових функцій та складнішими умовами діагностики.*

Ключові слова: *травматичний розрив макули, мінно-вибухова травма, контузія очного яблука, розрив макули, оптична когерентна томографія, вітректомія, sclopetaria, сітківка.*

Introduction

Traumatic macular hole (TMH) is a relatively rare but clinically significant pathology which causes a significant central vision loss and substantially affects quality of life. In 1869, Knapp was the first to describe this condition in a young man who had sustained an eye trauma [1]. The incidence of TMHs is 1.4% in closed-globe trauma and 0.15% in open-globe injuries [2, 3].

In peacetime, they are uncommon and usually arise from a mixture of sports, domestic and work-related accidents. Several mechanisms of TMH formation have been proposed for such cases. The formation is commonly explained as follows. A sudden decrease in the anterior-posterior diameter causes a compensatory equatorial expansion, which can lead to horizontal forces and splitting of the retinal layers at the fovea [4].

During recent military campaigns, a change in the pattern of eye trauma has been observed, with a substantial increase in the incidence of blast-related trauma (BRT) and gunshot injuries to the eye. Such injuries have a combined mechanism involving shock wave effects, abrupt intraocular pressure (IOP) fluctuations and direct mechanical tissue damage. This results in the formation of more severe and disseminated lesions of the posterior segment, particularly macular lesions. BRT is frequently accompanied by the development of multiple ocular comorbidities such as traumatic cataract, vitreous hemorrhage, subretinal hemorrhages, retinal detachment, choroidal rupture, and chorioretinitis sclopetaria [5]. When combined, these conditions make the clinical picture more complicated, worsen the functional prognosis, and create a challenge in the diagnosis of macular hole.

Optical coherence tomography (OCT) is the gold standard for the diagnosis of TMH and enables evaluating the morphology and size of the tumor, the state of retinal layers and concomitant structural changes. Minimum hole diameter (defined as the shortest distance across the defect) and base diameter (defined as the widest distance at the level of the retinal pigment epithelium (RPE)) are the two most commonly used key parameters [6].

Macular holes can be classified as small (< 250 µm), medium (250-400 µm), or large (> 400 µm) [7].

Morphometric indices are also used for predicting the course of the disease. Particularly, a macular hole index (ratio of hole height to base diameter) of ≥ 0.5 is believed to be associated with a favorable prognosis. The hole form factor (the ratio between the overlying tissue dimensions and the hole base diameter) is additionally assessed and is also of a prognostic value.

There is no universal approach for selecting the optimal TMH closure technique. Small (< 250 µm) macular holes in young patients tend to close spontaneously within 3-6 months, especially in the absence of posterior hyaloid detachment and apparent intraretinal cysts [8-11]. Surgical treatment (often including pars plana vitrectomy (PPV) with internal limiting membrane (ILM) peeling) is indicated if the hole shows no improvement towards closure or in the presence of ocular comorbidity [12].

Although TMHs contribute only a small percentage to overall ocular trauma profile, the clinical significance of this disorder is very high. The fact that most patients are working-age adults determines not only medical but also social and economic significance of the disease. An increase in the incidence of severe eye trauma in wartime necessitates an in-depth study of the features of TMHs, particularly, the features depending on the mechanism of damage.

The purpose of the study was to examine the clinical features of TMHs secondary to globe contusion versus those secondary to blast-related ocular trauma based on the review of medical records of patients visiting SI “The Filatov Institute of Eye Diseases and Tissue Therapy of the National Academy of Medical Sciences of Ukraine” in 2018-2025.

Material and Methods

We retrospectively reviewed the medical records of patients with TMH who underwent examination and treatment at SI “The Filatov Institute of Eye Diseases and Tissue Therapy of the National Academy of Medical Sciences of Ukraine" in 2018-2025. A total of 35 patients aged 9 to 50 years (mean age, 36 ± 7 years) were included. Of these, 34 (97.14%) were males and one (2.86%) was female. The diagnosis of TMH was based on the history and ophthalmoscopic and OCT findings. The diagnosis was made intraoperatively in a portion of patients with marked media opacity or vitreous hemorrhage. Based on others definitions [13], TMHs with a size of 0.1-0.2 disc diameters (3 cases, 17.64%) were defined as small, and those greater than 0.5 DD (5 cases, 29.4 %) were defined as large.

Patients were divided into two groups based on the mechanism of trauma, with group 1 including 18 patients (18 eyes) with TMH secondary to globe contusion, and group 2, 17 patients (17 eyes) with TMH secondary to blast-related ocular trauma (BROT).

Macular hole morphology and location were evaluated and comorbid injuries were analyzed. Best-corrected visual acuity (BCVA) was assessed at baseline and follow-up visits.

Minimum hole diameter and base diameter were determined if OCT images of adequate quality were available. Minimum hole diameter was defined as the shortest distance across the defect and base diameter as the widest distance at the level of the RPE. The shape of the defect and state of the adjacent layers were also assessed.

Treatment strategy was selected taking into account the patient's age; mechanism of trauma; hole size, morphohology and duration; and the presence of any comorbid injuries. Patients (especially young patients) with small (< 250 µm) TMH who did not receive primary surgical treatment were followed up for 3 months with regular OCT to evaluate the possibility of spontaneous closure. The decision for surgery in patients with moderate (250–600 µm) TMH was made if (1) there were no signs of gradual spontaneous closure, (2) visual function was consistently low or (3) there was comorbid pathology. Early surgical treatment was the preferred option in patients with large (> 600 µm) TMH. Surgical intervention included PPV with ILM peeling. The inverted ILM flap technique was used in large macular holes to increase the probability of anatomical closure.

This paper is part of the research program to Determine the Features of Vitreoretinal Surgery for Macular Disease in Wartime (registration number № 0125U002074) and Advance the Restorative-and-Reconstructive Surgical Treatment for Combat Ocular Trauma (registration number № 0126U001871).

Non-parametric statistical methods were applied. Qualitative parameters are presented as numbers and percentages. Fischer's exact test was used for group comparison. Significance was established at $p < 0.05$. Microsoft Excel was used for statistical analysis.

Results

Our review of cases enabled identification of substantial differences between TMHs secondary to globe contusion and those secondary to BROT.

There was ophthalmoscopic and OCT evidence that the former were commonly smaller than the latter and were predominantly oval (Fig. 1). TMHs secondary to BROT had more apparent morphological changes; they were larger, round and exhibited apparent retinal cystic changes along the edge of the hole (Fig. 2). In a portion of patients in group 2, in was impossible to determine accurately the dimensions of the hole preoperatively due media opacity or vitreous hemorrhage.

Additionally, there were significant between group differences in location of choroidal comorbidities. Choroidal ruptures were located centrally or parafoveally in TMHs secondary to globe contusion, and mostly subfoveally in those secondary to BROT.

There were also substantial between group differences in the distribution of BCVA among patients before and treatment.

At baseline, in the group of TMHs secondary to globe contusion, BCVA was light perception in 1 patient (5.55%), ranged from 0.48 LogMAR to 2.3 LogMAR in most (14/18) patients (77.78%), and was better than 0.48 LogMAR in 3/18 patients (16.67%). The number of patients with BCVA better than 0.48 LogMAR increased to 10 (55.56%), and BCVA still ranged from 0.48 LogMAR to 2.3 LogMAR in 8 patients (44.44%) in this group after treatment.

At baseline, in the group of TMHs secondary to BROT, BCVA was light perception in 6 patients (35.29%), with the BCVA of light perception being more common in this group (35.29% versus 5.55%; $p < 0.05$, by Fischer's exact test). Additionally, BCVA ranged from 0.48 LogMAR to 2.3 LogMAR in 10 patients (58.82%), and was better than 0.48 LogMAR in only 1 patient (5.89%). Moreover, after treatment, no substantial improvement in visual acuity was observed, with a BCVA better than 0.48 LogMAR being still substantially less common than in the group of TMHs secondary to globe contusion (5.89% versus 55.56%; $p < 0.01$ by Fischer's exact test), and 12 patients (70.59%) having a BCVA ranging from 0.48 LogMAR to 2.3 LogMAR, and 6 patients (35.29%), a BCVA of light perception.

Another substantial difference between groups was in the frequency of ocular comorbidities. Ocular comorbidities were relatively uncommon in the group of TMHs secondary to globe contusion, with 3 patients (16.67%) having traumatic cataract, and 4 patients (22.22%), isolated peripapillary choroidal ruptures.

In the group of TMHs secondary to BROT, however, ocular comorbidities were relatively common, with the most common being vitreous hemorrhage (5 cases, 29.41%), multiple choroidal ruptures (5 cases, 29.41%), and chorioretinitis sclopetaria (5 cases, 29.41%), followed corneal opacity (4 cases, 23.5%). Estimation of the TMH size in patients in this group was complicated by poor visualization of the defects, with 8 cases (47%) being diagnosed intraoperatively.

An important difference between groups was in the dynamics of improvement towards closure. Spontaneous hole closure occurred over 3 months in 3 patients (16.67%) in the group of TMHs secondary to globe contusion, with these holes being as small as less than 300 μm, and these three patients being young. In such cases, over the period of observation, there was a gradual reduction in the size of the defect, with subsequent restoration of the anatomical integrity of the fovea and improvement in visual function (Fig. 3).

In the group of TMHs secondary to BROT, spontaneous hole closure was seen only in one patient (5.8%) and occurred one month after the traumatic event. Over the period of observation, most cases showed no signs of spontaneous defect closure, thus providing an indication for surgery. This indication was supported by the presence of ocular comorbities such as vitreous hemorrhage, retinal detachment and choroidal ruptures.

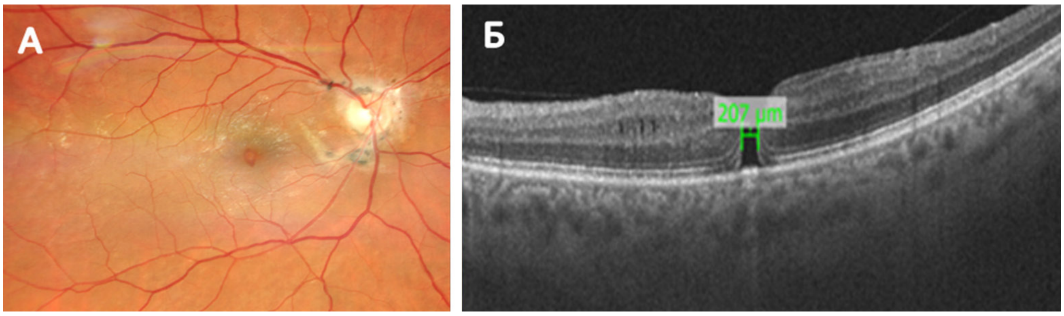

Fig. 1. Fundus photography (A) and OCT image (B) of the macula in a traumatic macular hole secondary to globe contusion

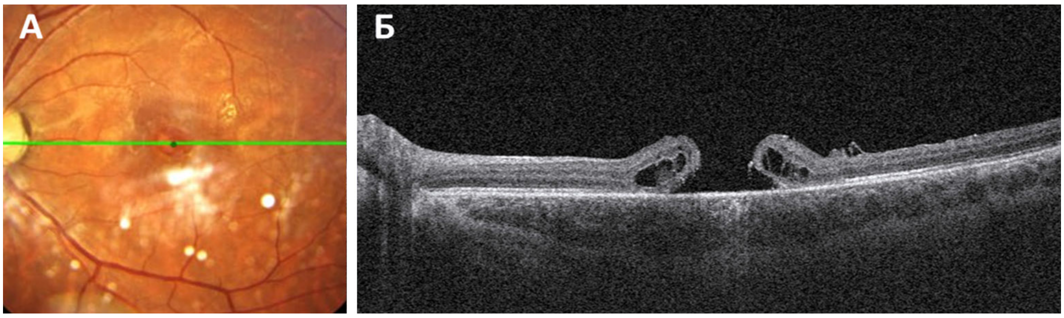

Fig. 2. Fundus photography (A) and OCT image (B) of the macula in a traumatic macular hole secondary blast-related ocular trauma (base diameter, 1575 μm; minimum hole diameter, 905 μm)

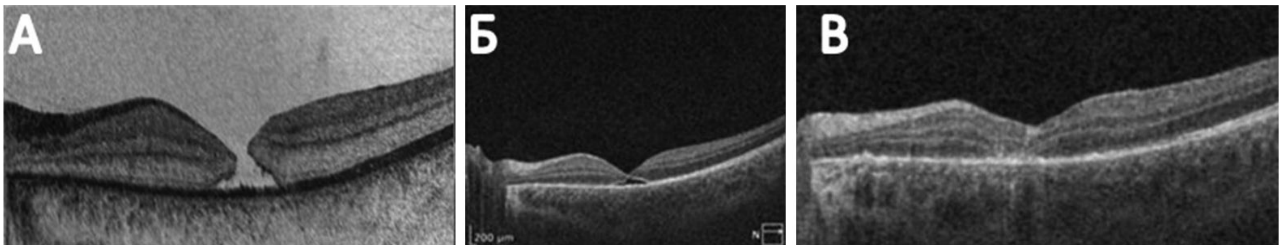

Fig. 3. OCT images showing spontaneous closure of a traumatic macular hole in a patient with globe contusion from a soccer ball at admission (A; BCVA was 6/20 and base diameter, 306 μm), day 3 (B; BCVA was 6/20) and day 10 after a traumatic event (C; BCVA was 6/12).

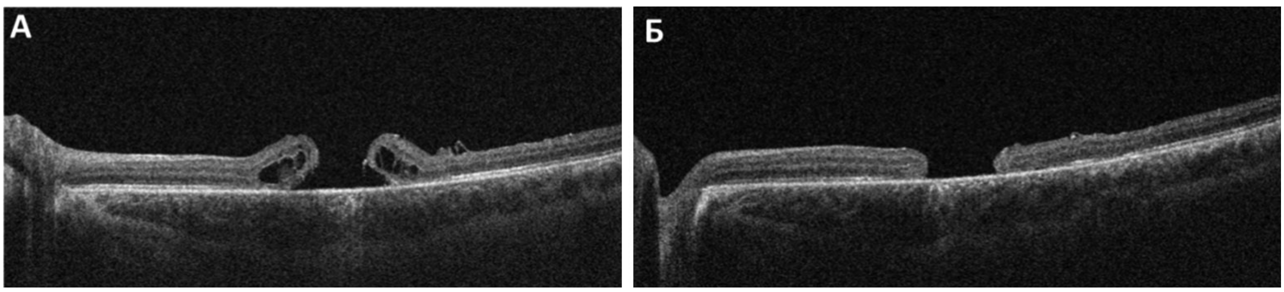

Fig. 4. OCT image of the macula in a patient with macular hole secondary to blast-related ocular trauma which failed to close after vitrectomy with inverted flap

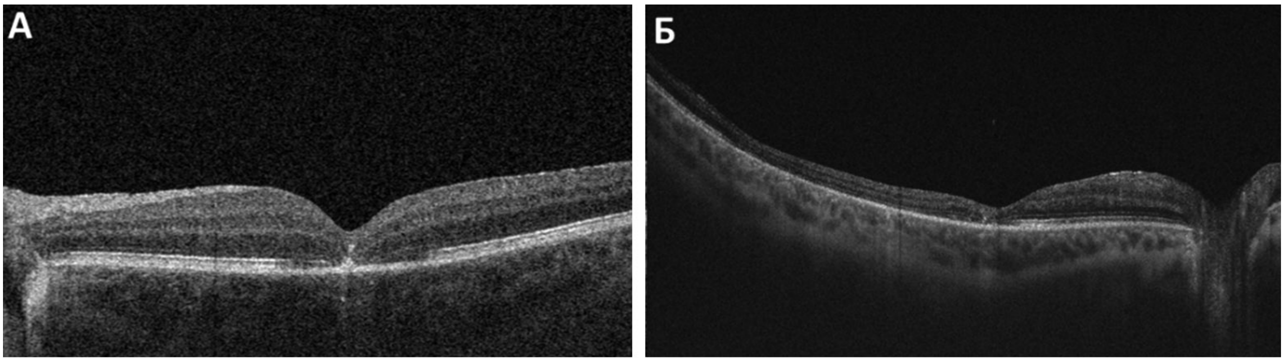

Fig. 5. Post-operative OCT images of a traumatic macular hole secondary to globe contusion, with a central retinal thickness of 276 μm (A) and that secondary to blast-related ocular trauma, with a central retinal thickness of 190 μm (B)

After treatment, the percentage of patients having a BCVA better than 0.48 LogMAR in the group of TMHs secondary to globe contusion increased from 16.67 % to 55.56 %, indicating a substantial functional improvement.

In the group of TMHs secondary to BROT, post-treatment functional improvement was less substantial, with 12 patients (70.59%) having a BCVA ranging from 0.48 LogMAR to 2.3 LogMAR, and 4 patients (23.52%), a BCVA of light perception. Additionally, surgery failed to achieve anatomical hole closure in two patients (12.5%) (Fig. 4).

Discussion

Our retrospective review indicated that the clinical course of TMH largely depended on the mechanism of trauma. Patients with TMH secondary to globe contusion had a relatively favorable course, whereas those with TMH secondary to BROT exhibited more severe macular lesions and worse functional treatment outcomes.

A possible spontaneous hole closure is a feature of TMHs. Spontaneous hole closure most commonly occurs in young patients with a small TMH within several months after surgery [5, 6, 9, 10, 14]. In the current study, spontaneous closure was found mostly in patients with TMH secondary to globe contusion, which confirms the appropriateness of observation over a short period in specific clinical situations.

BROT was accompanied by more apparent structural abnormalities in the posterior segment of the eye than contusion-related trauma. This study found that a larger hole size, the association with choroidal ruptures and a high frequency of vitreoretinal comorbidities were characteristic for TMH secondary to globe contusion. This is associated with the fact that a combination of both a shock wave and abrupt IOP fluctuations cause deeper vitreoretinal lesions than isolated globe contusion [15].

Therefore, the findings of this study confirm that TMH secondary to globe contusion and that secondary to BROT are the two different clinical pathogenetic conditions. This necessitates a differential approach to the diagnostic evaluation, selection of treatment strategy and prediction of functional outcomes depending on the mechanism of trauma.

Macular holes have been found in 20.8% of patients with chorioretinitis sclopetaria secondary to BROT [5]. Given that chorioretinal morphological OCT features in chorioretinitis sclopetaria secondary to BROT (but not in traumatic choroidal rupture secondary to globe contusion) include generalized subretinal fibrosis with apparent adherence of the edges of the TMH to the underlying RPE, even relatively small TMHs either have poor prognosis for closure or their closure is associated with low functional outcome.

Even after anatomically successful surgery with hole closure, visual function in patients with BROT were lower due to retinal alterations and thinning of the photoreceptor layer (Fig. 5). Therefore, patients with BROT had worse functional outcomes not only due to the morphological features of macular holes, but also due to the complex nature of ocular tissue lesions.

Hence, the findings of this study confirm that TMH secondary to globe contusion and that secondary to BROT are the two different clinical pathogenetic conditions. This necessitates a differential approach to the diagnostic evaluation, selection of treatment strategy and prediction of functional outcomes depending on the mechanism of trauma.

Conclusion

Substantial clinical and morphological differences between TMHs secondary to globe contusion and those secondary to BROT determine the course and prognosis of these TMHs.

The former are commonly smaller than the latter and predominantly oval and may spontaneously close, with better functional outcomes.

TMHs secondary to BROT are relatively large and round, which causes a significant central vision loss.

Visual function is significantly worse in these TMHs compared to those secondary to globe contusion, which is due to deeper macular lesions and limited potential for the recovery of macular anatomy. A differential approach to the diagnostic evaluation of TMH secondary to BROT is required because this evaluation is more difficult.

Author Contributions

KKS: Data Curation, Data Analysis, Writing - original draft preparation; UNA: Conceptualization, Data Curation, Writing – Review and Editing; IaIV: Data Curation, Data Analysis, Writing - original draft preparation; UMM: Conceptualization, Data Curation, Writing – Review and Editing

Conflict of interest

The authors state that they have no conflict of interest that could influence their view on the subject matter or materials described and discussed in this manuscript.

Sources of support

None.

Disclaimer

The opinions presented in this article are those of the authors and do not necessarily represent those of their institution.

Abbreviations

BCVA, best-corrected visual acuity; BRT, blast-related trauma; OD, optic disk; TMH, traumatic macular hole.

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