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Forensic Examination and Systematic Assessment of Ocular Injuries in Living Individuals

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Abstract: The article is devoted to a comprehensive forensic medical characterization of ocular injuries in living individuals. Modern approaches to the classification of ophthalmic trauma are examined, including etiological, mechanical, and anatomical-topographical criteria that allow for a more precise determination of injury patterns and their pathogenetic features. The mechanisms of formation of various types of injuries—from blunt and penetrating to combined and blast-related—are analyzed in detail, which is essential for reconstructing the circumstances of injury and for accurate expert interpretation. Particular attention is given to the diagnostic capabilities of contemporary imaging technologies, such as optical coherence tomography, ocular ultrasonography, and orbital computed tomography. These methods provide high accuracy in detecting subtle, minimally expressed, and deep structural alterations that remain inaccessible during traditional clinical examination. Criteria for determining the degree of harm to health are presented, based on a comprehensive assessment of functional impairment, long-term consequences, and the risk of irreversible loss of visual functions. The pivotal role of commissioned (panel) forensic medical examinations in complex, controversial, iatrogenic, and conflict situations—where multidisciplinary analysis is required—is emphasized.The findings contribute to the improvement of expert assessment algorithms and promote the unification of approaches to evaluating ocular trauma in contemporary forensic medical practice.

Keywords: Forensic Medicine, Ocular Trauma, Eye Injury, Organ of Vision, Injury Mechanism, Severity Assessment, Imaging, OCT, Orbital CT, Examination

Introduction

Trauma to the organ of vision in living individuals represents one of the most complex categories of forensic injuries due to the high functional significance of the eye, its vulnerability, and the pronounced variability of clinical manifestations [1]. According to epidemiological data, ophthalmic injuries account for up to 10–15% of cases of temporary or permanent visual impairment, which determines their high social and forensic importance [2].

For a forensic expert, the accurate determination of the mechanism of injury, the anatomical and topographic characteristics of the damage, and its functional consequences is of particular importance, as these parameters form the basis for assessing the severity of harm to health [3]. Modern international guidelines emphasize the necessity of a comprehensive approach, including the analysis of objective clinical data, correlation with the circumstances of the incident, and the use of high-precision imaging methods [4].

Imaging techniques such as optical coherence tomography (OCT), ocular ultrasonography, and orbital computed tomography significantly expand diagnostic capabilities in the forensic analysis of ophthalmic injuries, allowing the detection of both superficial and deep lesions that may not be apparent during a standard examination [5].

Particular complexity is presented by iatrogenic injuries resulting from diagnostic or therapeutic interventions. Their forensic assessment requires the correlation of standards of care, medical documentation, and the potential risks associated with specific procedures [6]. In such cases, the role of collegial analysis becomes increasingly important, as confirmed by international forensic practice. Thus, the need for the unification of approaches and the objectification of criteria for evaluating ocular trauma determines the relevance of comprehensive forensic investigation in this field [7].

Objective of the study – to identify the types and nature of ocular trauma.

Materials and Methods

The study material consisted of a retrospective analysis of 56 forensic medical examination reports conducted in the outpatient department of the Tashkent City Branch of the Republican Scientific and Practical Center for Forensic

Medical Examination during 2021–2022. Medical records (case histories) were also analyzed, as all the individuals involved had undergone inpatient treatment. Standard research methods were employed, including radiological, macroscopic, and statistical analyses.

Results and Discussion

According to the obtained data, ocular trauma was identified in all examined cases. Among the patients, there were 39 men (69.64%) aged 14–66 years and 17 women (30.36%) aged 20–50 years. Combined ocular injuries accounted for approximately 66.67% of all eye traumas. Based on the victims' statements and case circumstances, ocular injuries were most frequently sustained during fights and in domestic settings [8]. The following types of ocular trauma were identified: penetrating (18.67%) and blunt (80.33%); injuries of the eyelids and orbit (72.78%) and injuries of the conjunctiva and sclera (27.22%); single (78.22%), double (14.44%), and multiple (7.33%); unilateral (75.56%) and bilateral (24.44%); contusions of the eye (87.11%) and orbital wall fractures (12.89%); with fragment displacement (24.22%) and without displacement (75.78%); direct (85.89%) and indirect (14.11%) [9]. Analysis of the materials submitted for examination revealed that in many cases the injuries were of mild severity. Damage to the organ of vision included disruption of the integrity of the anterior and posterior segments of the eye, as well as surrounding soft tissues of the orbital region [10]. Penetrating injuries were characterized by defects of the cornea or sclera, compromising the integrity of the eyeball and posing a risk of intraocular structure prolapse. Incomplete injuries (partial tears, microcracks) manifested as preservation of the integrity of certain corneal or scleral layers, accompanied by localized edema and hemorrhage [11].

The most typical areas of injury included the cornea, limbal region, anterior chamber, iris, lens, as well as peri- and intrabulbar segments. Traumatic damage to the posterior segment encompassed retinal tears, vitreous hemorrhages, and optic nerve injuries. Injuries to the eyeball were generally accompanied by changes in the soft tissues of the periorbital region, including abrasions, eyelid contusions, hematomas, wound defects, edema, and hemorrhages of varying severity [12].

In some cases, the diagnosis of ocular injuries was significantly complicated due to pronounced edema of the eyelids and periorbital soft tissues. In certain instances, palpation of the orbital rim allowed the detection of tenderness, the "step" sign, and localized crepitus, which are characteristic of orbital wall fractures. An indirect loading sign was also observed, manifested by pain upon pressing on the opposite rim of the orbit. Examination of the conjunctiva and the surface of the eyeball revealed conjunctival tears, hemorrhages of various localizations, deformation of the eyeball contours, and abnormal mobility or displacement of the eyeball in cases of orbital wall injuries[13].

Orbital radiography in direct and lateral projections demonstrated disruption of the integrity of the orbital bony structures. It should be noted that fractures of the medial or inferior orbital wall were more frequently diagnosed using more precise methods, such as computed tomography (CT), which allowed visualization of bone fragment displacement and the presence of foreign bodies. When blunt-force trauma is applied to the orbital region, the mechanism of injury typically involves displacement of bony fragments under the influence of the impact force and negative pressure within the orbit. In cases of unilateral orbital fractures, the eyeball may be displaced downward and backward, accompanied by diplopia and restricted ocular mobility due to muscle entrapment [14].

In cases of bilateral injuries or extensive destruction of the inferior orbital wall, enophthalmos may occur, which is associated with significant impairment of visual function and the development of life-threatening complications, including optic nerve compression, disruption of ocular blood supply, and the risk of irreversible vision loss [15].

Conclusion

Ocular injuries have high forensic significance, as they often lead to persistent functional impairments and require precise determination of the mechanism of injury. A comprehensive approach to the diagnosis of ophthalmic trauma is essential, including clinical examination, imaging techniques (OCT, ocular ultrasonography, orbital CT), assessment of visual functions, and analysis of the circumstances of the injury.

The classification of ophthalmic injuries should take into account the mechanism of impact, the anatomical and topographic level of the lesion, the severity of the injury, and the potential prognosis, ensuring objectivity in

forensic evaluation. Modern imaging methods significantly enhance diagnostic accuracy, allowing the detection of hidden or subtle injuries of ocular and orbital structures that are not apparent during routine examination.

Injuries to the eyeball and orbit are often accompanied by damage to the surrounding soft tissues, which necessitates careful documentation and correlation of morphological findings with the presumed mechanism of trauma. Assessment of the severity of harm to health should be based on quantitative criteria of functional impairment, including decreased visual acuity, limitation of ocular movements, and signs of permanent loss of visual functions.

In complex, disputed, or iatrogenic cases, collegial forensic examination plays a key role, minimizing diagnostic errors, resolving discrepancies in conclusions, and increasing the reliability of expert opinions.

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