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Research Article

CLASSIFICATION, CLINIC AND DIAGNOSIS OF ORBITAL FRACTURES (LITERATURE REV)

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ABSTRACT

Orbital contusion trauma is characterized by particular severity, a high risk of blindness, the possibility of the development of purulent-inflammatory complications, and functional and cosmetic defects [1]. The multiple nature of traumatic injuries necessitates the use of accurate topical diagnosis and treatment planning. The study of traumatic lesions of the orbit is relevant.

KEYWORDS

Contusion injury, orbit, fractures.

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INTRODUCTION

Orbital contusion trauma accounts for 36 to 64% of all injuries to the facial skeleton involving the visual organ and its accessory organs [1, 2]. About 85% of all orbital injuries requiring inpatient treatment are bone wall integrity disorders [3].

According to epidemiological studies, in Russia, there is an absolute prevalence of domestic (64.5%) orbital injuries over criminal (21.7%) and occupational (15.5%) injuries [1, 4]. This pattern is not so much due to a decrease in the number of criminal and occupational orbital injuries per se, as to the fact that in many cases they are reported by the patient as domestic [5]. Many authors have noted an increase in orbital transport injuries in the last 5 years, from 4.9% in 2007 to 12.8% in 2010, due to an increase in the number of vehicles, high road speeds, and alcohol consumption behind the wheel [2, 6, 7].Orbital injuries are often the result of sports activities [3]. According to the data of employees of ophthalmology department of Perm medical institute in 10 years (2000 - 2010) the sports traumatism accounts for 9 - 11 % of fractures of bones of the medial zone of facial skeleton [8].

The bones of the middle zone of the facial skeleton are also involved in the formation of the orbit, so injuries to this zone are reflected in the nature of damage to the bony walls of the orbit. Fractures of the midface are associated with orbital fractures in 80% of cases [4], with isolated fractures of the lower orbital wall being the most common, accounting for 6-12% [9]. In 29 - 37% of patients, fractures of two orbital walls are identified. Fractures of three orbital walls were reported in 12 - 18 % of patients and all four walls in 3 - 7 % of patients. In the structure of all orbital diseases in peacetime, according to the Military Medical Academy of St. Petersburg (MMA St. Petersburg), orbital damage ranges from 2% to 8% [4], and in children it is 0.9% [10]. In children, fractures of the bony walls of the orbit in blunt trauma account for 23% of all facial injuries. Of all orbital fractures encountered in pediatric practice, 25 to 70% are linear fractures of the inferior wall without displacement of the fragments, a trap fracture with impingement of the inferior rectus muscle [3, 11]. Orbital trauma is combined with injuries of ENT organs in 92 %, maxillofacial region in 47 %, skull and brain bones in 45 %, other organs in 11 % of cases,

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according to data of the Military Academy of St. Petersburg. In 65-66% of cases, orbital trauma is combined with contusions of the eyeball and its accessory organs [4, 12]. The ophthalmology literature distinguishes between orbital soft tissue contusion without orbital fracture and with fracture (13). Most cases of orbital contusion injury are unilateral, with bilateral injury occurring less frequently. In terms of incidence, orbital bone wall fractures in orbital contusions are one of the most common midface injuries and account for 31% [3]; in children, 23% of all left skeletal injuries [10]. Orbital contusions without fracture occur in 78% of all orbital injuries (13).

The social significance of orbital trauma is determined by the young working age of the patients, with a bimodal distribution of orbital contusions with peak frequency at the ages of 16-21 and 39-55 years, reduced adaptation to working life with diplopia in 89%, resulting in significant economic losses [6, 14].

A significant difference was found in the gender distribution of orbital trauma, with three quarters of the victims being men [3].

The possibility of seasonality in the incidence of orbital trauma was also investigated. For example, it has been noted that the number of orbital bone wall fractures increases sharply between April and October; according to other data, this occurs between July and September [2].

In an analysis of the population of orbital trauma victims, 42% of cases were found to be under the influence of alcohol at the time of injury.

- Classification of orbital trauma. According to Gundorova's classification (2009), orbital trauma is divided into domestic, transport, criminal, occupational, sports, agricultural, man-made, and pediatric [1].
- In the literature, the only complete classification of orbital fractures is proposed by Nikolaenko V.P. (2009), according to which the most common types of orbital fractures, which may occur in isolation or in various combinations with other facial injuries, are identified.- "Blast and depressed fractures of the inferior wall of the orbit;
- Explosive and depressed fractures of the inner wall of the orbit;
- Fractures of the zyco-orbital complex;
- Le Fort I, II, III* fractures of the upper jaw;
- Nasoethmoid fractures;
- "Blasted" and depressed fractures of the upper orbital wall;

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- Fronto-basal fractures (including supraorbital, glabellar, and isolated fractures of the superior orbital margin);
- Fractures of the orbital apex, including concomitant damage to the optic nerve canal;
- Local fractures caused by sharp objects inserted into the orbit.
- *Top jaw fractures account for 2-5% of all facial bone fractures. The most common classification of maxillofacial fractures is LeFort (1901). It distinguishes between three main fracture types (3).
- Inferior (LeFort-I; transverse). Its line runs in the horizontal plane. Starting at the edge of the sternal foramen on both sides, it runs to the back above the level of the floor of the maxillary sinus and passes through the tubercle and the lower third of the pterygoid process of the sphenoid bone.
- Medial (Lefort-II; suborbital).
- Its line runs through the junction of the frontal process of the maxilla with the nasal part of the frontal bone and the nasal bones (nasolabial suture), then runs down the medial and lower walls of the eye socket, crosses the bone along the suborbital margin and reaches the pterygoid process of the sphenoid bone. The cervical bone with the crenoid plate is often injured.Upper (Lephorus-III; subbasal). Its line runs through the nasolabial suture, along the inner and outer walls of the eye socket, up to the upper part of the pterygoid process and the body of the sphenoid bone. At the same time the zygomatic process of the temporal bone and the nasal septum are broken vertically. This causes the facial bones to separate from the skull bones. The orbit is affected by subbasal and suborbital fractures. Traumatic fractures of the upper jaw are bilateral according to LeFort classification, and their lines run symmetrically. The typical location of fracture lines is rare, more often the fracture line is atypical or asymmetrical [13].Scientific papers focus on the inferior wall, as it is the most frequently injured in orbital trauma.According to the classification of A. C. Kiselev (2006) identified types of 'blast' fractures of the lower orbital wall:

- Small splintering, when the lower orbital wall is "scattered" into a large number of small fractures and is practically absent in a certain area, depending on the fracture;
- Large splintering, consisting of one or two large fractures that sink into the cavity of the

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maxillary sinus together with the tissues of the eye cavity;

- The fractures do not lose their connection with the bone and tend to return to their original position, impinging on the ocular tissues that are wedged between them.

In addition, Prof. V. P. Ippolitova (2004) developed a classification of post-traumatic deformities of the midface based on the clinical and radiological picture of zygomatic-orbital complex (SOC) injuries. M. Khitrina (2007) based on her classification, developed a working scheme for fractures of the zygomaticorbital complex (SOC), features:

Excludes the term "fracture of the zygomatic bone" as the fracture lines are always localized outside the zygomatic bone with involvement of the orbital margins and walls.

Considers the multiple fractures of the MRL and highlights the localisation of the maximal displacement and diastasis, which facilitates the choice of surgical treatment.

5 fracture groups:

1. Fractures of the SSS with maximal fragment displacement and diastasis along the inferior orbital margin.
2. Fractures of the CEA with maximal displacement of the fragments and diastasis along the zygomatic suture.
3. Multiple SDS fractures without pronounced diastasis between the fragments.
4. Fractures of the ETS combined with fractures, orbital floor defect.
5. Fractures of the zygomatic arch [15].

According to the working classification of Gorbunova E. Д. (2006) fractures of the lower orbital wall in children according to clinical and radiological signs: presence and terms of disappearance of diplopia, limitation of eyeball mobility, transverse size of the through defect, magnitude of displacement of the lower orbital wall towards the maxillary sinus, presence of CT signs of orbital soft tissue impingement in the fracture area.

1. CT - signs of fracture with transverse size of the penetrating defect up to 0.5 cm and minimal displacement of the lower orbital wall up to 0.2 cm, without signs of orbital soft tissues impingement in the fracture zone.

Clinical signs (diplopia, limitation of mobility) disappear on the 2nd - 5th day.

2. CT - signs of fracture with transversal dimension of the penetrating defect more than 0,5 cm and displacement of the lower orbital wall more than 0,2 cm, without signs of impingement of orbital soft tissues in the fracture zone. Clinical signs (diplopia, limitation of mobility of the eyeball) disappear on the 7th to 10th day.
3. CT - signs of a fracture with impingement of the orbital contents and its prolapse into the maxillary sinus. The clinical signs (disruption of ocular mobility, double vision, enophthalmos, including progressive enophthalmos) remain unchanged [10].

Definition and mechanism of orbital contusion injury. An orbital contusion is a closed, non-dermal injury resulting from blunt force (contusion, compression) to the bony walls of the orbit and its contents [1].

Blunt orbital trauma is caused by a blow in which the injuring object is in motion: a blow with a fist, leg, stick, log, puck, ball, swing; or in which the subject remains motionless: a fall to the ground from a height (from a tree, bicycle), a traffic accident [11, 13]. A detailed assessment of the mechanism of orbital trauma in a contusion is helpful in making the diagnosis. For example, if the blunt solid object is smaller than the orbital inlet, the patient may develop a subconjunctival scleral tear without damage to the orbital bone walls. If the size of the damaging object is larger than the orbital inlet, there are two possibilities: with the impact of an agent with relatively low velocity and low kinetic energy, an "explosive" fracture of the orbital wall (lower or inner); with a strong impact, a combined fracture (lower ocular margin and the orbital floor or inner wall; upper ocular margin and inner wall, the orbital roof) [1]. If the impacting object is large and has high kinetic energy, it causes not only a fracture of the "bone ring" of the orbit, but also of other facial bones, up to and including the formation of panfacial fractures [3].

The type of injury in orbital contusions is determined by the condition of the eyeball and the anatomical features of the orbital structure. If the outer membranes of the eye are incomplete, e.g. after keratotomy or scleromalacia, the eye "capsule" is torn and this "saves" from a fracture. The normal eyeball in a contusion does not rupture with a blunt flat blow, but deforms and shifts deep into the orbit, compressing its

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contents and sharply increasing intraorbital pressure, which causes the weakest lower wall of the orbit to push into the maxillary sinus [3, 15, 16].

The anatomic structure of the lower orbital wall - thin periosteum, honeycomb structure of the cancellous substance, and topographic location - nodal position in the system of natural bone connections of the orbit result in a high incidence of isolated and combined fractures in 87.3 %. Less common are isolated and combined external, upper, and internal wall fractures in 15.8% [1, 9]. Takizawa et al. (1998) demonstrated from experiments and subsequent computer simulations that the contour (profile) of the orbital walls plays an important role. In particular, an arch-shaped orbital roof is much more resistant to deformation than a nearly flat bottom, which deforms and breaks more easily. The inner wall of the orbit is even thinner, but the lattice labyrinth cells reinforce it at the back like buttresses, so more mechanical energy is required to fracture the medial wall than to fracture the orbital floor [3, 13]. The reflex contraction of the orbital circular muscle and the presence of a large air cavity beneath the orbit also contribute to more frequent damage to the lower orbital wall (17). It is the underdevelopment of the maxillary sinus and the continued growth of the orbit that accounts for the rarity of orbital floor fractures in children under 7-8 years of age [3,18].

In 'straight' fractures the zygomatic bone is injured and 'breaks out' along the joints connecting it to the frontal, temporal and maxillary bones. The entire force of the impact falls on the edges of the orbit, causing them to fracture or terminate in the formation of fractures in the trauma area, or spread inward along the walls. Such a fracture is accompanied by almost complete loss of the lower orbital wall [19].

The clinical presentation of orbital trauma in contusion in the acute period is determined by the localization of the fracture of the orbital bone wall. Symptoms of fracture of the lower orbital wall are well described: oedema, eyelid haematoma, hypophthalmos, bulbar conjunctiva chemosis, downward displacement of the eyeball (hypophthalmos), limitation of active and passive eye movements, impaired sensitivity in the zone of innervation of the suborbital nerve [1, 3].

Symptoms of fracture of the inner wall of the orbit are not as clear as those of the lower wall:

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emphysema of the eyelids, conjunctiva, unilateral nasal bleeding. In the case of a fracture of the inner wall of the orbit, enophthalmos with impingement of the internal rectus muscle in the fracture zone has been observed [9, 20]. In this type of fracture, the medial ligament of the eyelids, the lacrimal ducts and the lacrimal sac can also be damaged [1].In fracture of the upper orbital wall, along with a severe general state of the patient, eyeball movement disorders, upper orbital slot syndrome, pulsating exophthalmos, anisocoria due to impaired pupillary innervation, optic nerve damage in the bone canal, opto-nerve path, lycvoria, "glasses symptom" are common [1, 21]. Symptoms of fracture of the external wall of the orbit, which includes the zygomatic complex (facial asymmetry, disruption of the contour of the zygomatic bone, limitation of lateral and downward movements of the lower jaw when opening the mouth). There is also displacement of the eyeball, limitation of active and passive movements, and damage to the external commissure of the eyelid [1, 13].The complexity of the clinical examination of patients with orbital trauma is due, on the one hand, to the uniformity of clinical symptoms in various orbital and optic nerve injuries, on the other hand, to the inaccessibility of the orbit for examination and limited known examination techniques, and the difficulty of differential diagnosis with intracranial and optic tract injuries [3].Clinical Examination This explains the importance of the radiological diagnosis stage, which aims to clarify and confirm the clinical diagnosis, develop an optimal treatment strategy and determine the prognosis of orbital trauma [1, 22].

The diagnosis of orbital trauma in contusion is difficult due to the need to use various instrumental methods to examine the orbit (3). Radiological diagnosis is the leading method for examining the orbit. The diagnosis of traumatic injuries to the orbital bone structures begins with traditional cranial radiography in straight, lateral and anterior semiaxial projections, or orbital radiography in 2 projections. In case of suspicion of injuries of the posterior wall of the orbit, optic nerve canal, frontal, metacarpal bone, the targeted X-ray of the orbital region is carried out by the method of O. According to different authors, many time-consuming radiological examinations are not very informative and often mislead the doctor and significantly delay the diagnosis. The probability of error (missed X-ray fracture diagnosed by subsequent coronary computed tomography) is 10 - 13% for an inferior

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wall fracture and 20 - 27% for an inferior wall fracture. However, radiography is 100% effective in diagnosing a fracture of the upper and outer orbital wall [3, 10, 22, 23, 24]. Therefore, at present, X-rays of the skull and orbital cavity in frontal, lateral and anterior semiaxial views are used only at the admission stage as a screening method. When analysing the radiographs obtained, attention is mainly paid to indirect signs of orbital damage: darkening of the orbit due to marked swelling of the eyelids and retrobulbar tissue in the area of damage, air in the upper parts of the orbit.

It can diagnose gross fractures of the orbital wall, large bone fragments, and haemosinus by obscuring the sinus cavity adjacent to the fracture area [22].The disadvantages are that it is not possible to assess changes and the interposition of the soft tissues of the orbit with the bone structures (impingement, shape changes, muscle tears), and to determine the extent of the fracture towards the orbital apex and the width over the entire length. In radiography there is projection layering of bones, so it is impossible to get an idea of small fractures with small fragments or fractures of thin bones, comminuted fractures without significant displacement, establish the presence of bone fragment penetration into the skull cavity, sinus cavities. X-rays cannot be used to assess and decide if surgical intervention is necessary [6, 10, 23].

Conventional radiography can be limited to the determination of an extensive orbital fracture with an appropriate clinical picture. If the traditional radiological examination is positive and the radiologist gives a negative opinion and the clinician's suspicions remain, the patient is referred to a computed tomography (CT) scan for a detailed diagnosis of the features of orbital contusions (19). Emergency CT scanning is becoming the reality of our time as the method of choice. Although the optimal time for CT scanning is considered to be a delayed period after orbital trauma (soft tissue swelling reduction) [3, 25]. The advantages of CT scanning are its ability to differentiate tissues of different density due to high resolution (to define the condition of orbital bone structures, eye cavity and orbital contents), noninvasiveness, small time and financial expenses. Furthermore, CT scanning data can clearly visualize small and combined (several walls) fractures, estimate the size and position of bone fragments, diagnose complications of contusion trauma such as retrobulbar and

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subperiosteal hematoma, hemorrhage in subchain optic nerve space, extraocular muscles, and diagnose the condition of mucosa of accessory sinuses (signs of hemorrhage and inflammation) [3, 10].

A significant disadvantage of CT scanning, especially multiple scanning, is the radiation load on the lens [3, 26].

For a complete analysis of lesions of the orbital bone and its contents, the examination is performed in two planes at 1.25 mm increments. Coronal (frontal) tomograms are more informative when analysing deformities, defects of the lower and upper walls of the orbit, orbital herniation into the maxillary sinus or cerebral herniation into the orbit, tears and extraocular muscle-bone fusion sites. Axial slices better visualize fractures of the medial and lateral walls of the orbit, optic nerve and optic nerve canal, and the shape of the straight extraocular muscles [26, 27]. When analyzing CT data in unilateral fractures, attention is paid to the symmetry of the shape and volume of the orbit, the position of the eyeballs and extraocular muscles, the condition of the optic nerve and its bone canal, and the presence of foreign bodies [1, 28]. In normal cases the eyeball occupies a central position in the orbit, its displacement close to any wall shows the impingement of the corresponding muscle in the fracture zone. The shadows of straight muscles are normally 0.1-0.3 cm away from the bone walls. If there is no X-ray-negative stripe between the muscle and bone, scar fusion or impingement of the muscle and bone is suspected [3, 10, 26]. Minor comminuted fractures are characteristic of "blast" fractures of the orbit with damage to the thin bones of the labyrinth or the lower orbital wall.

Fractures in the form of a fracture are usually found in 'blast' fractures (lower wall fracture) and fractures of the frontal bone (upper wall fracture). The CT scan helps to identify secondary involvement of the inferior and inner rectus muscles near the displacement of bone fragments in blast fractures of the orbital wall, differentiates the causes of diplopia due to muscle impingement and muscle haematoma development, and helps to identify parabulbar soft tissue prolapsed into the sinuses adjacent to the orbit [1, 27, 28]. Coronary imaging may be impeded by the patient's poor general condition, the presence of an intubation tube in the trachea (its image overlays the orbital contours), or trauma to the neck preventing hyperextension. In these cases,

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spiral computed tomography (SCT) or multidetector spiral computed tomography (MSCT) are indispensable. They are characterized by high diagnostic informativeness, high scanning speed, possibility of imaging orbits in bone and soft tissue modes, creating 3D and multiplanar reformations based on multiple slices - high frequency scanning. In addition, overextension of the neck is no longer necessary to obtain coronal slices [29, 30].Many authors claim that CT and MSCT techniques will eliminate the need for magnetic resonance imaging (MRI) in patients with orbital trauma. However, the use of these techniques in the diagnosis of orbital contusion injury has been reported in the literature by a few authors [31].

In addition, a method of noninvasive low dose (2 mSv) functional MSCT (fMSCT) of extraocular muscles in orbital trauma was developed by the staff of the Sechenov First Moscow State Medical University Department of Radiation Diagnostics. The study is performed in dynamic scanning mode according to the program of bone and soft tissue reconstruction with a slice thickness of 0.5 mm in axial projection, followed by obtaining multiplanar and three-dimensional reconstructions with simultaneous eye movement in a certain sequence. When fMSCT is performed in the presence of functional muscle activity, extraocular muscle fixation in the fracture zone can be detected. In the absence of movement and contractility of a muscle, paralysis of nerves involved in muscle innervation can be confirmed or muscle detachment from the eyeball from the vertex of the orbit can be diagnosed [32]. These include the presence of a pacemaker, metal implants, permanent makeup and tattoos (which create artifacts and impede the interpretation of images), claustrophobia, pregnancy and lactation, and uncontrolled movements of the patient during the examination. MRI can be used to assess the anatomico-topographical relationship of the orbital structures to the sinuses and brain [1,31].

Ultrasound (ultrasound; two-dimensional imaging system) of the orbit and eyeball structures for orbital contusions, allows you to see a cross-section of the eye in a given scanning plane with its structural changes. Ultrasound can assess the shape, size, clarity of contours, structure, echogenicity of eyeballs, as well as the location and size of the main intraocular structures: cornea, anterior chamber, iris, ciliary body, lens, vitreous body, retina, vasculature;

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condition of optic nerve area, retrobulbar space, extraocular muscles [32, 33].

In recent years, ultrasound diagnosis of orbital fractures in contusive orbital trauma has been actively introduced [34]. The main arguments are economic feasibility, widespread availability of ultrasound equipment, also the absence of radiation exposure and the possibility of long-term investigation. The use of ultrasound to diagnose fractures of the lower edge and anterior parts of the orbital floor proved to be the most justified; the method was proposed by Medvedev Y.A. and Konyakhin A.F. (2007). The principle of the method consists in drawing on the patient's face the scheme of the location of ultrasound probes to study the bone tissue throughout the fracture line on the injured side and the same amount of bone tissue on the undamaged side, taking into account the complex topography and anatomico-topographic structure of the midface bones.Based on this method, it is determined that the rate of ultrasound signal transmission is slower on the injured side compared to the healthy side, in the dynamics the line of injury approaches the indicators of the healthy side. Dynamic studies provide data on the course of reparative processes along the fracture line, enable timely transition to functional treatment, assess a particular method of fixation of bone fragments, and reduce the number of radiological studies [35].

In conclusion, the incidence of blunt orbital trauma among all injuries to the facial skeleton involving the visual organ and its accessory organs ranges from 36 to 64%. In the early stages, the uniformity of clinical symptoms does not allow a precise topical diagnosis to be made. Different diagnostic methods (X-ray, CT, MSCT, fMSCT, MRI, ultrasound) are currently used to diagnose the localization of the orbital injury site. However, the published literature does not provide clear indications for the use of each of these methods. To systematize and build an effective, targeted algorithm for the examination of patients with blunt orbital trauma is the task of our further research.

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