Pre- and postoperative orbital MSCT imaging in patients with zygomatico-orbital trauma

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Authors: O. Pavlova, N. Serova; Moscow/RU
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Aims and objectives

The problem of zygomatico-orbital complex trauma retains its high relevance and significance as it is constantly recorded growing rates of facial trauma [1,7]. Besides, both type and character of the trauma have become more severe and complicated [5]. The zygomatico-orbital trauma is believed to be a significant problem due to several points. First of all, in Russia disability rate is very high - 23.5% [6]. Considering that and the fact that males of the 20-50 years are the most prevailed group proper diagnostic workup and treatment are very important [2]. Secondly, the zygomatico-orbital trauma is one of the most commonly recorded injuries, with 24-33% of all maxillofacial injuries [4,5,6]. Nevertheless, visual impairment rates in the zygomatico-orbital injury come up to 33-36,3%, that is why the problem of possible posttraumatic visual and ocular movement impairment is equally important [8]. Therefore the role of well-timed and accurate pre- and postoperative diagnostic imaging in such injuries is essential in order to provide efficient treatment [3,4]. In our study we want to emphasis the necessity of correct evaluation of all orbital soft-tissue elements, as well as the bony structures in zygomatico-orbital trauma before and after the surgical treatment using MSCT.
Methods and materials

A total of 50 patients (44 males/6 females, age range 15-64 years) with zygomatico-orbital trauma were admitted to the hospital on 1-3 day after the injury. Road traffic accident was the most common etiological factor in 28 patients followed by violence in 18 and sports trauma in remaining 4 cases. The majority of patients have unilateral fractures, in 3 cases - two-sided injuries after severe road traffic accident.

Preoperative MSCT scan was performed at the day of admission. Postoperative MSCT images were obtained within 7-10 days after the surgery. 40-slice MSCT data was completed with MPR in coronal and sagittal views and 3D images. Post processing of the MSCT data included workstation special software, where the bone borders of the orbit were marked on every axial slice and then presented in mathematical units (ml). Orbital walls and margins were reconstructed with implants and osteosynthesis elements.
Results

Preoperative MSCT allowed bone fractures assessment (Fig.1): orbital floor (n=50, 100%), lateral (n=50, 100%), medial (n=8, 16%) and superior (n=3, 6%) orbital walls. It is important to remember that presence of pathological substrate and emphysema in the ethmoidal cells could be an indirect sigh of medial wall fracture. MSCT helped to reveal big or small bony fragments that affected soft tissue structures such as oculomotor muscles (n=8, 16%), nerves or lacrimal glands (n=1, 2%).

Preoperative MSCT assessment of soft tissue injury (Fig.2): herniation of orbital contents into the adjacent maxillary sinus with formation of enophthalmos (n=11, 22%) and increased orbital volume (n=14, 28%). MSCT provided detailed information about globe trauma (n=2, 4%), injured optic nerve (n=11, 22%), affected oculomotor muscles (n=18, 36%), lacrimal glands (n=1, 2%) and orbital emphysema (n=8, 16%).

Postoperative MSCT helped to assess position of implants and osteosynthesis elements, reconstructed anatomical units and condition of surrounding bone and soft tissues. In case of satisfactory outcome MSCT visualized reconstructed anatomical contours resulting in almost normal orbital volume without any herniation and enophthalmos (Fig.3).

Complications of incorrectly implanted elements included remaining herniation of orbital content in the posterior part of orbital cavity and enophthalmos (n=3, 6%), increased orbital volume (n=6, 12%), globe trauma (n=2, 4%), deformation of optic nerve (n=6, 12%) and affected oculomotor muscles (n=3, 6%) (Fig.4).

Postoperative MSCT findings along with the clinical examination could be crucial in surgeon's decision to reintervention in case of incorrect positioned orbital floor implant (Fig.5).

As in the example, MSCT demonstrates pre- and postoperative dynamic in patient with satisfactory results (Fig.6).

Post processing of the MSCT data gave the possibility to calculate pre-and postoperative orbital volume changes and present it in mathematical units (Fig.7). In some cases when the volume changes aren't that obvious it could be helpful to provide additional information about the severity of patient's condition.

However, there are some disadvantages of MSCT that should be taken into consideration. First of all, it is radiation exposure. That is why the examination requires exact indications. The other important issue concerns metal artifacts. The artifacts could seriously influence the visualization of the surrounding tissues and therefore, the ability of radiologist to diagnose inflammatory changes in bone tissue that is in intimate position to
metallic elements. In such situations cone-beam computed tomography (CBCT) is more preferable for long-term dynamic.
**Fig. 1:** Advantages of MSCT in assessing bone fractures (different cases). A. 3D MSCT image shows increased orbital volume because of the injured left zygomatico-orbital complex (compared to the normal orbital volume on the right). B. Coronal MSCT reveals multiply fractures of the superior (short thick arrows) and inferior (long thin arrow) orbital walls resulting in increasing left orbital volume. C. Axial MSCT shows multiply fractures of the left medial (short thick arrow) and lateral (long thin arrow) orbital walls with pathological substrate in the ethmoidal cells. D. 3D MSCT image evaluates fractures of left zygomatic bone, as a component of the inferior and lateral orbital walls. E. Axial MSCT, affected lateral rectus muscle by a bony fragment of the injured lateral wall on the left. F. Axial MSCT reveals orbital emphysema (short thick arrows) on the left.

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Fig. 2: Advantages of MSCT in assessing soft tissue injury (different cases). A. Coronal MSCT, herniation of orbital fat and inferior rectus muscle (which appeared thickened as compared to the opposite side) into the adjacent left maxillary sinus. B. Axial MSCT, formation of left enophthalmos due to multiply bone fractures. C. Axial MSCT, absence of the right globe as a consequence to severe zygomatico-orbital trauma. D. Coronal MSCT, affected inferior rectus muscle by a bony fragment of injured right orbital floor. E. Axial MSCT, convolute appearance of affected right optic nerve (E1) compared to the normal left one (E2, same patient). F. Axial MSCT, dislocated right lacrimal gland as a consequence to injured and displaced bone fragments of the lateral orbital wall.

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Fig. 3: Advantages of MSCT in assessing correct position of the implanted metallic elements (different cases). A. 3D MSCT image assesses right orbital floor implant and infraorbital margin's osteosynthesis elements. B. Coronal MSCT allows evaluating structure and position of left orbital floor implant and condition of the surrounding bone tissue. C. Sagittal MSCT shows correct anatomical cone-shaped position of reconstructed orbital floor. D. Coronal MSCT, anatomically reconstructed two-sided injured orbital floors. E. 3D MSCT image assesses evaluation of osteosynthesis elements in area of right frontozygomatic suture (short thick arrow) and infraorbital margin (long thin arrow). F. Sagittal MSCT provides detailed visualization of osteosynthesis elements in the area infraorbital margin and anterior sinus wall.

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Fig. 4: Advantages of MSCT in assessing incorrect position of the implanted metallic elements and complications due to it (different cases). A. Coronal MSCT shows reconstruction of the two-sided injured orbital floors: the almost normal right orbital volume versus remaining increased left orbital volume and enophthalmos due to incorrect position of the orbital floor implant. B. Coronal MSCT allows to evaluate unusual reconstruction of right orbital floor using two implants resulting in soft tissue entrapment between them. C. Coronal MSCT reveals right orbital floor implant (short thick arrow), which does not cover the posterior part of the orbital floor, resulting in remaining herniation of orbital fat into the adjacent maxillary sinus. D. Sagittal MSCT shows minor prolapse of the posterior part of the implant into the adjacent maxillary sinus (short thick arrow). E. Sagittal MSCT shows significant prolapse of the posterior part of the implant into the adjacent maxillary sinus (short thick arrow). F. Sagittal MSCT shows upward prolapse of the posterior part of the implant into orbital cavity affecting inferior rectus muscle (short thick arrow).

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Fig. 5: Clinical case that illustrates MSCT diagnostics of incorrectly reconstructed orbital floor and complications due to it (the same patient). 1a,b,c. The upper line is referred to the patient's condition after the right orbital floor reconstruction. The medial side of the implant affects medial rectus muscle (1b, 1c, short thick arrow). 2a,b,c. The lower line is referred to the patient's condition after the replacement of the right orbital floor implant, so no muscles are affected. (2b, 2c, short thick arrow). Note the removed infraorbital osteosynthesis elements after the second operation (1a, 2a, short thick arrow).

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Fig. 6: MSCT in pre- and postoperative visualization of the injured zygomatico-orbital structures (the same patient before and after the operation). The upper line is referred to the patient's condition before the operation. Multiply fractures and herniation of orbital content into the adjacent left maxillary sinus (1a, 1c) with formation of enophthalmos (1b). Left orbital volume is increased in comparison with normal right one. The lower line is referred to the patient's condition after the operation. There is no herniation of orbital content (2a, 2c) and no enophthalmos (2b). Left orbital volume is almost completely normal.

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**Fig. 7:** Post processing of the MSCT data that calculates pre-and postoperative changes in orbital volume and presents it in mathematical units (the same patient before and after the operation as in the previous illustration). The illustrations allows to reveal left orbital volume before (1a,1b,1c*) and after (2a,2b,2c*) the operation and compare it to the normal right side. Before the operation difference in volumes was more than 14 ml, after the surgery it became approximately 4,6 ml. [* - view from the top].

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Conclusion

Currently postoperative MSCT is used as a control investigation of patient's condition along with the clinical examination. It provides detailed information about postoperative effects of bone and soft-tissue structures after severe zygomatico-orbital trauma. It also gives the possibility to calculate pre- and postoperative changing orbital volume and present it in mathematical units. If performed on time (within 7-10 days after the surgery), MSCT allowed assessment of all injured orbital contents in order to exclude possible serious posttraumatic complication like visual or ocular movement impairment.
References