

ОРИГИНАЛЬНАЯ СТАТЬЯ

ORBITAL VOLUME ASSESSMENT ACCORDING TO MSCT DATA IN PATIENTS WITH MIDFACE TRAUMA

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Purpose. To acquire additional diagnostic information in patients with orbital trauma in order to identify the risk of postoperative enophthalmos. To evaluate the advantages of MSCT data postprocessing and volume orbital measurement.

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Materials and methods. A total of 71 patients (100%) with midface trauma were studied in Sechenov University using pre- and postoperative volume 640-slice CT. Post processing of MSCT data included workstation special software, where the bone borders of the orbits before and after surgical treatment were marked on every slice and presented in mathematical units (ml).

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Results. Preoperative MSCT revealed increased orbital volume in 64 patients (90%) due to severe midface trauma, the difference between traumatized and normal orbit was from 2 ml to 14 ml, these patients required surgical treatment. The other 7 patients (10%) had mild midface trauma, the difference between orbital volumes was less than 2 ml, these patients didn't undergo surgical treatment.

After the operation in 55 patients (77%) the orbital volume was reconstructed - the difference between orbital volumes was not more than 2 ml. In 9 cases (13%) orbital volume difference was more than 2 ml which means that these patients still had risk of postoperative enophthalmos and required additional diagnostic control and potential surgical correction.

Conclusion. Postprocessing of the MSCT data gave the possibility to calculate pre- and postoperative orbital volume changes and present it in mathematical units (ml) in 3D mode. As the result the additional information can be acquired in order to identify the risk of postoperative enophthalmos.

Keywords: MSCT, data postprocessing, enophthalmos, volume orbital.

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МЕТОДИКА ОЦЕНКИ ОБЪЁМОВ ОРБИТ ПО ДАННЫМ МСКТ У ПАЦИЕНТОВ С ТРАВМОЙ СРЕДНЕЙ ЗОНЫ ЛИЦА

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Цель исследования. Разработать методику измерения объёмов орбит у пациентов с травмой средней зоны лица на до- и послеоперационном этапах лечения на основе данных МСКТ. Изучить возможности измерения объёмов орбиты с целью получения дополнительной диагностической информации для оценки риска развития энофтальма.

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Материалы и методы. В клинике Сеченовского Университета был обследован 71 пациент (100%) с травмой орбиты. На до- и послеоперационном этапах обследования всем пациентам (n=71, 100%) была выполнена мультиспиральная компьютерная томография на аппарате Toshiba Aquilion One 640, с толщиной среза 0,5 мм, в костном и мягкотканном режимах. Для измерения объёмов орбиты обработка МСКТ данных проводилась на рабочей станции Vitrea и включала в себя маркировку костных

границ правой и левой орбиты до и после хирургического лечения на каждом аксиальном срезе с представлением объёмов орбит в мл.

Результаты. Обработка МСКТ данных на предоперационном этапе показала увеличение объёма травмированной орбиты у 64 пациентов (90%), различия объёмов здоровой и травмированной орбит составили от 2 мл до 14 мл. Данной группе пациентов было проведено реконструктивное хирургическое лечение. У 7 пациентов (10%) с травмами средней зоны лица легкой степени тяжести различия в объёмах орбиты не превышало 2 мл, что является положительным прогностическим фактором, данные пациенты получали консервативное лечение.

После хирургического лечения у 55 пациентов (77%) объём травмированной орбиты восстановился, разница объёмов здоровой и травмированной орбит составила менее 2 мл. В 9 случаях (13%) разница объёмов здоровой и травмированной орбит составила более 2 мл, что является неблагоприятным прогностическим фактором и говорит о сохраняющемся риске развития энофтальма. У пациентов данной группы необходимо проведение дополнительного диагностического обследования в раннем и позднем постоперационном периодах.

Выводы. Разработанная методика обработки МСКТ данных дает возможность определять изменения объёмов здоровой и травмированной орбит на до- и послеоперационных этапах лечения. В результате методика оценки объёмов орбит даёт возможность получения дополнительной диагностической информации для оценки риска развития энофтальма.

Ключевые слова: МСКТ, обработка данных, энофтальм, объём орбиты.

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Nowadays the problem of midface and orbital trauma retains its high relevance and significance as it is constantly recorded growing rates of facial trauma [1, 4, 6, 7, 8, 11, 13, 14, 17, 22, 24]. Orbital trauma often results in persistent both aesthetic and functional impairment including complete or partial vision loss, different injury of oculomotor muscles system, deformation of paranasal sinuses and airways [1-5, 11, 15, 18, 23]. One of the most typical and important clinical features is a multiply injury which includes bone and soft tissues and brain trauma. Besides, both type and character of the trauma have become more severe and complicated and could lead to patients' disability [1-4, 9, 12, 19, 25]. According to the WHO data, incidence of orbital trauma is increasing world widely every year due to the urban growth, developing mechanization and various substance abuse. Males of the working age are the most exposed group with average disability rate about 23,5% [1, 2, 4, 6, 8, 10, 16, 20].

Therefore the role of proper pre- and postoperative diagnostics using multislice computed tomography (MSCT) in such injuries is very important and can hardly be overestimated [3, 4, 5, 6, 7, 10, 21].

However, it is not enough to only perform correct and well-timed diagnostic modality to establish the fact of orbital trauma. Nowadays top-priority aim in diagnostic procedures in patients with orbital trauma is development of special postprocessing of the MSCT data to acquire additional diagnostic information in order to establish the effective patient's management [3, 4, 20-25].

Purpose.

To acquire additional diagnostic information in patients with orbital trauma in order to identify the risk of postoperative enophthalmos. To evaluate the advantages of MSCT data postprocessing and volume orbital measurement.

Material and methods.

A total of 71 patients (100%) with midface trauma were studied in Sechenov University using

pre- and postoperative volume 640-slice CT (Toshiba Aquilion One 640).

Scanning parameters: area of interest – facial skeleton, scanning mode – volume, slice thickness – 0,5 mm, field of view – 16 sm, voltage – 100 kV, current intensity – 60 mA, time of scanning – 1-2 sec, reconstruction type – bone. A patient is lying on the back during the study, the patient's head is fixed on the headrest.

For measurement of orbital volumes post processing of MSCT data included workstation special software, where the bone borders of the orbits before and after surgical treatment were marked on every slice and presented in mathematical units (ml).

According to the developed method of orbital volumes calculating, a patent was obtained RU (11) 2 638 623 (13) C1, 14.12.2017 Bul. № 35.

The method of orbital volume's measurement:

1. Definition of the bone orbital borders, where the marking will take place, were performed. The necessity for the correct study implementation is the symmetry of the bone borders for both orbits. To determine the external marking border, it is necessary to draw a line through the entire length of the orbit and to build perpendicular to its length, performed for both orbits at once (Fig. 1).

2. On every axial slice the orbital bone borders were marked from the superior orbital wall to the level of orbital floor (Fig. 2). For the measurements accuracy, it is necessary to strictly observe the bone borders and take into account the anatomical variations of orbital walls, as well as the areas of damage orbital walls.

3. After the orbital volume measurement acquired results compared before and after the reconstructive surgery (Fig. 3).

Results.

Preoperative MSCT revealed increased orbital volume in 64 patients (90%) due to severe midface trauma, the difference between traumatized and normal orbit was from 2 ml to 14 ml.

These patients required surgical treatment, because it is believed that with a difference in orbital volumes more than 2 ml, globe displacement increases by 1 mm and, as a result, the risk of enophthalmos increases, which is a reliable prognostic factor and can be used for planning and evaluation of the surgical treatment effectiveness. The other 7 patients (10%) had mild midface trauma, the difference between orbital volumes was less than 2 ml, which is a positive prognostic factor, these patients didn't undergo surgical treatment.

After the operation in 55 patients (77%) the orbital volume was reconstructed - the difference between orbital volumes was not more than 2 ml. In 9 cases (13%) orbital volume difference was

more than 2 ml which means that these patients still had risk of postoperative enophthalmos. These patients require additional diagnostic control and potential surgical correction with performance of control MSCT for dynamic in the early and late postoperative periods.

Clinical case.

A male patient, 59 y.o., was admitted to the Sechenov University within 48 hours after face trauma (fall from height, 2nd floor).

During the clinical examination, changed facial configuration and increased right paraorbital area due to soft tissue edema was determined, as well as skin abrasions, hematomas in the upper and lower eyelids, narrowing of the right ocular gap, numbness of the infraorbital region. Vision or globe movement impairment was not revealed.

MSCT was performed using Toshiba Aquilion One 640 scanner, volume mode, slice thickness 0,5 mm, bone and soft tissue reconstruction. For postprocessing of MSCT data workstation «Vitrea» was used.

MSCT revealed fracture of the right orbital floor and lateral wall, anterior and lateral maxillary sinus walls and fractures of zygomatic arch, there was no herniation of orbital content into the maxillary sinus (Fig. 4). The fracture localized in the lateral and central area of orbital floor.

According to the MSCT "raw" data, it was not possible to estimate the change in the right orbit volume for comparison with the contralateral side. For this purpose, a special technique was used to process CT images, calculate the volumes of both orbits and present them in ml for a detailed assessment of orbital post-traumatic changes.

For the postprocessing of MSCT data definition of the bone orbital borders, where the marking will take place, were performed. The necessity for the correct study implementation is the symmetry of the bone borders for both orbits. To determine the external marking border, it is necessary to draw a line through the entire length of the orbit and to build perpendicular to its length, performed for both orbits at once. On every axial slice the orbital bone borders were marked from the superior orbital wall to the level of orbital floor. For the measurements accuracy, it is necessary to strictly observe the bone borders and take into account the anatomical variations of orbital walls, as well as the areas of damage orbital walls

The difference between the affected and normal orbits according to the orbital volume assessment was 0,4 ml (Fig. 5). According to the literature data it is believed that with a difference in orbital volumes more than 2 ml, globe displace-

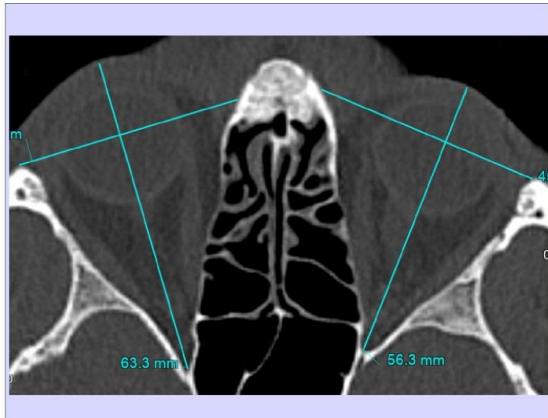


Рис. 1 а (Fig. 1 а)



Рис. 1 б (Fig. 1 б)

Fig. 1. MSCT, midface, bone window, axial reconstruction (A, B).

Definition of external orbital borders.

Рис. 1. МСКТ, средняя зона лица, костный режим, аксиальная реконструкция (А, Б).

Определение наружных границ обит.



Рис. 2 а (Fig. 2 а)

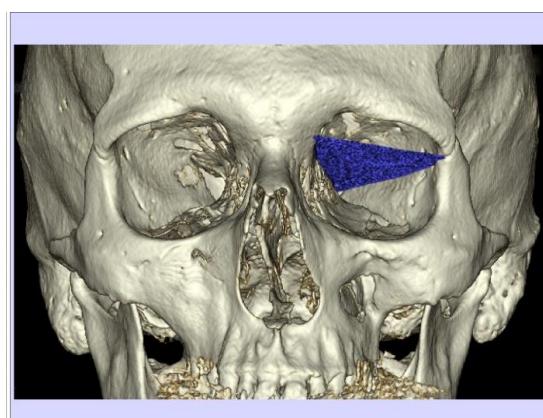


Рис. 2 б (Fig. 2 б)

Fig. 2. MSCT, midface, bone window, axial (A) and 3D (B) reconstruction.

Orbital bone borders were marked on every axial slice.

Рис. 2. МСКТ, средняя зона лица, костный режим, аксиальная (А) и 3D реконструкции (Б).

Маркировка костных границ орбиты.

ment increases by 1 mm and, as a result, the risk of enophthalmos increases, which is a reliable prognostic factor and can be used for planning and evaluation of the surgical treatment effectiveness. Thus, in this patient the risk of developing post-traumatic enophthalmos is minimal. Considering the absence of visual impairment and orbital bony and soft tissues complications, this patient underwent conservative therapy and diagnostic control in the post-traumatic period.

As part of a dynamic control, MSCT was performed 2 years after the injury. The obtained images showed restoration of the right orbit bone walls, as well as restoration of the right maxillary sinus walls and zygomatic arch, while the deformation of the lateral sinus wall was revealed (Fig.

6). There was no herniation of orbital content into the maxillary sinus.

According to the MSCT “raw” data, it was not possible to estimate the change in the right orbit volume for comparison with the contralateral side in late posttraumatic period. For this purpose, a special technique was used to process CT images, calculate the volumes of both orbits and present them in ml for a detailed assessment of orbital post-traumatic changes (Fig. 7).

The difference between the affected and normal orbits in the late posttraumatic period was 0,67 ml which was a good prognostic factor and showed minimal risk of posttraumatic enophthalmos development.

Conclusion.

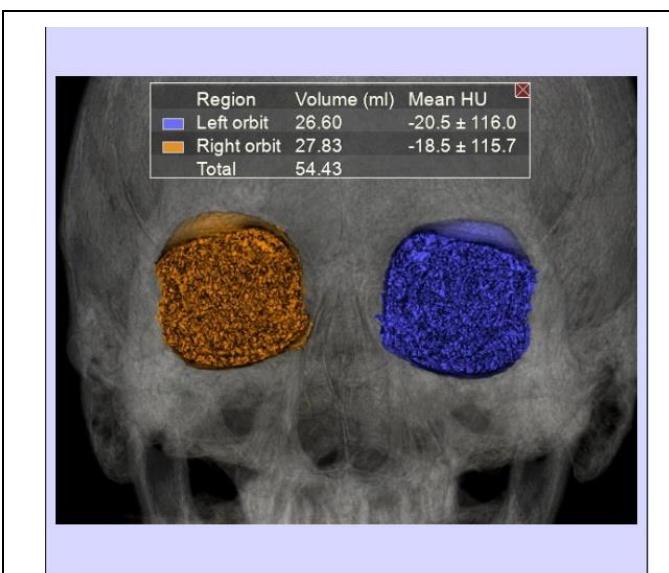


Рис. 3 а (Fig. 3 а)

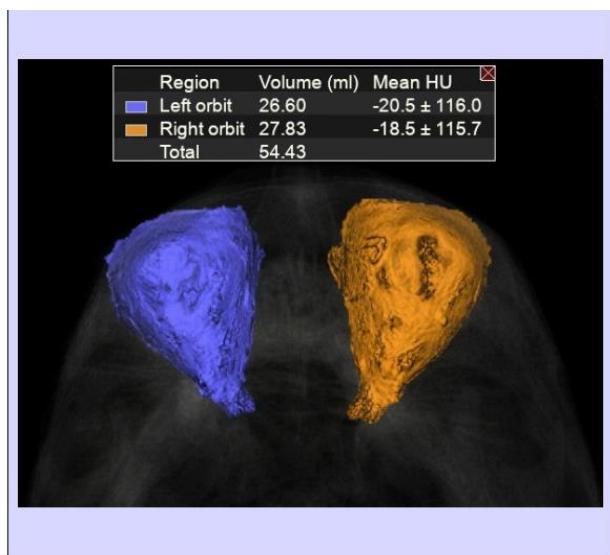


Рис. 3 б (Fig. 3 в)

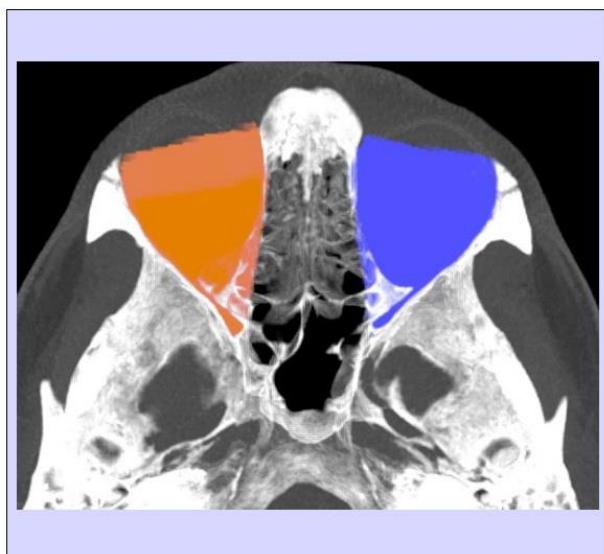


Рис. 3 в (Fig. 3 с)

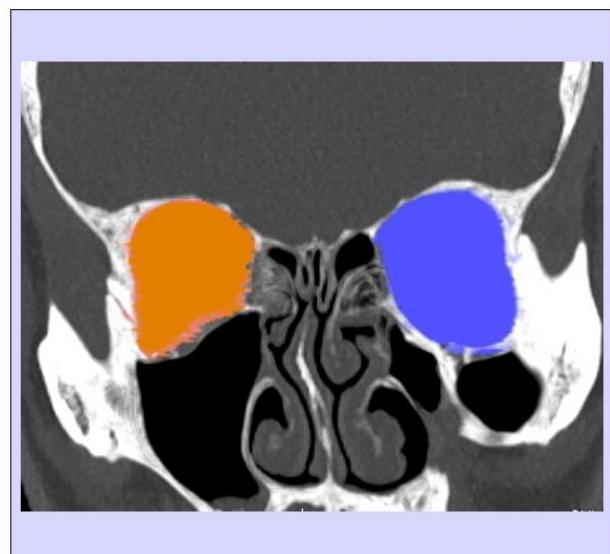


Рис. 3 г (Fig. 3 д)

Fig. 3. MSCT, midface, bone window, 3D (A), axial (B, C) and coronal (D) reconstruction.

Comparison of orbital volumes.

Рис. 3. МСКТ, средняя зона лица, костный режим, 3D реконструкция (А), аксиальная (Б, В) и коронарная (Г) реконструкции.

Сравнение значений объемов обеих орбит.

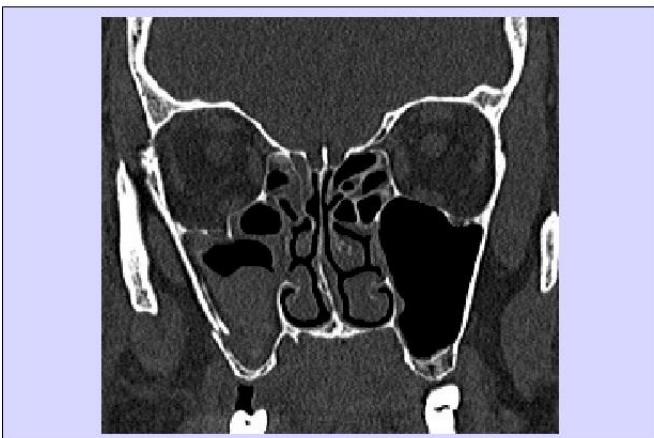


Рис. 4 а (Fig. 4 а)

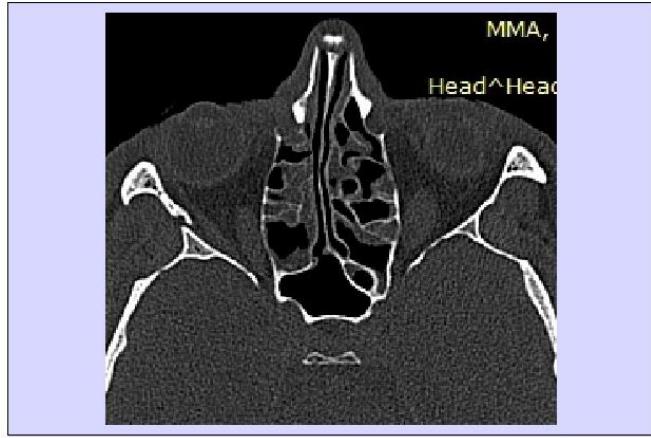


Рис. 4 б (Fig. 4 в)

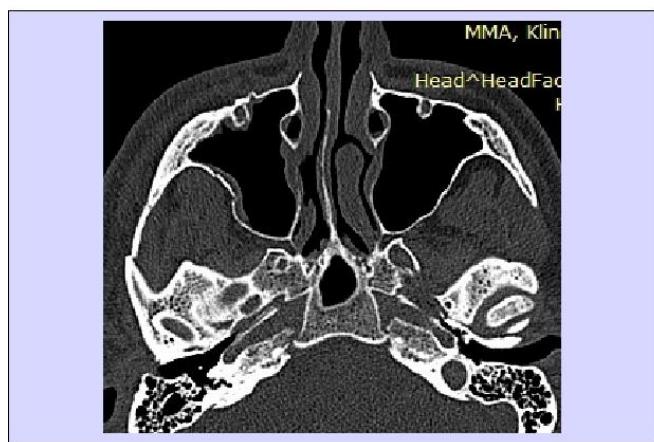


Рис. 4 в (Fig. 4 с)



Рис. 4 г (Fig. 4 д)

Fig. 4. MSCT, midface, bone window, coronal (a), axial (b, c) and sagittal (d) reconstruction.

MSCT revealed fracture of the right orbital floor and lateral wall, anterior and lateral maxillary sinus walls and fractures of zygomatic arch, there was no herniation of orbital content into the maxillary sinus.

Рис. 4. МСКТ, средняя зона лица, костный режим, коронарная (а), аксиальная (б, в) и сагиттальная (г) реконструкции.

Травматические повреждения лицевого скелета справа: перелом латеральной и нижней стенок правой орбиты, перелом латеральной и передней стенки правого верхнечелюстного синуса в области скуло-верхнечелюстного шва и двойной перелом правой скуловой дуги.

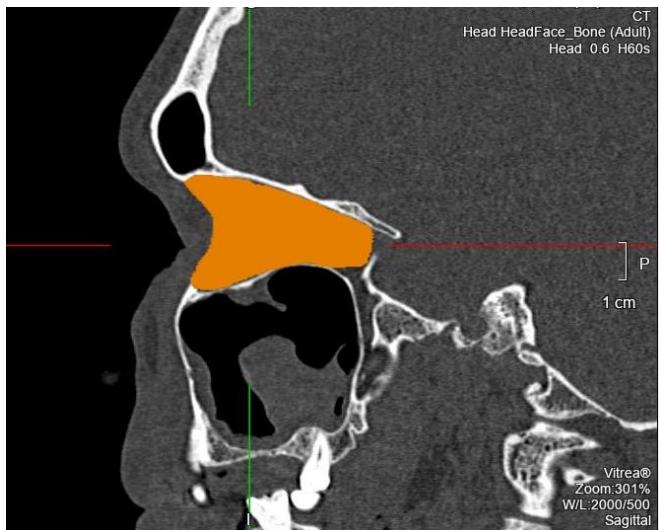


Рис. 5 а (Fig. 5 а)

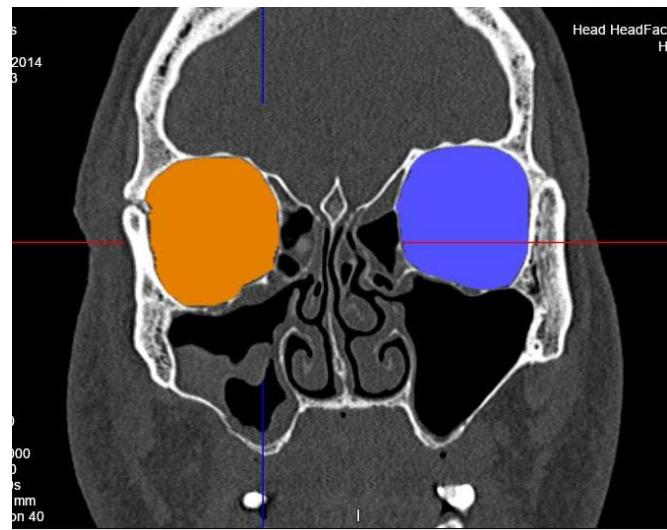


Рис. 5 б (Fig. 5 в)

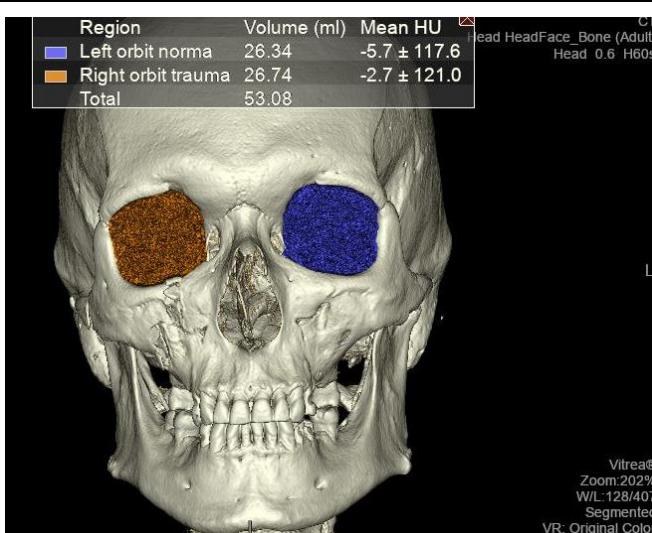


Рис. 5 в (Fig. 5 с)

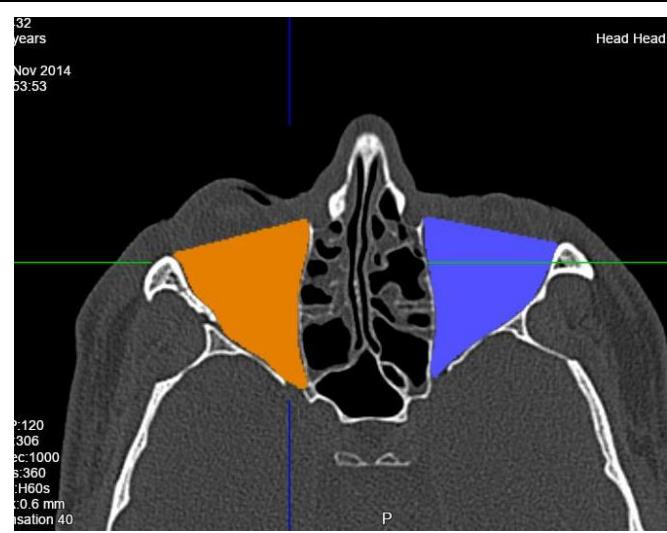


Рис. 5 г (Fig. 5 д)

Fig. 5. MSCT, midface, bone window.

Orbital volume assessment according to MSCT data in a patient within 48 hours after trauma using workstation. The difference between the affected and normal orbits according to the orbital volume assessment was 0,4 ml.

Рис. 5. МСКТ, средняя зона лица, костный режим. Измерение объемов орбит после травмы на рабочей станции.

При подсчете объемов поврежденной и здоровой орбит у данного пациента разница объемов в течение 48 часов после травмы составила 0,4 мл.

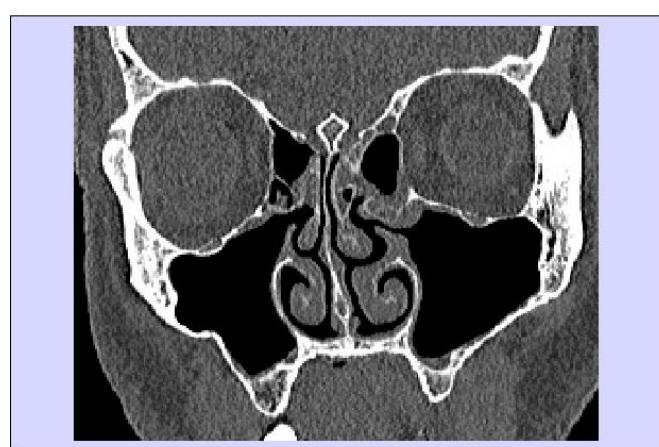


Рис. 6 а (Fig. 6 а)



Рис. 6 б (Fig. 6 в)



Рис. 6 в (Fig. 6 с)

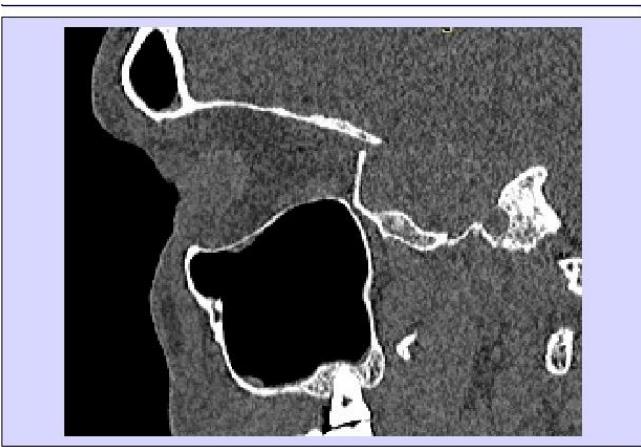


Рис. 6 г (Fig. 6 д)

Fig. 6. MSCT, midface, bone window, coronal (а), axial (б, в) and sagittal (д) reconstruction.

MSCT was performed in late posttraumatic period. There was reconstruction of orbital bony walls, maxillary sinus walls and zygomatic arch, as well as deformation of lateral maxillary sinus wall. There was no herniation of orbital content into the maxillary sinus.

Рис. 6. МСКТ, средняя зона лица, костный режим, коронарная (а), аксиальная (б, в) и сагиттальная (г) реконструкции.

На полученных изображениях отмечается восстановление костных стенок правой орбиты, а также восстановление стенок правого верхнечелюстного синуса и скуловой дуги, при этом визуализируется деформация латеральной стенки синуса. Пролабирования мягких тканей правой орбиты в верхнечелюстной синус не определяется.

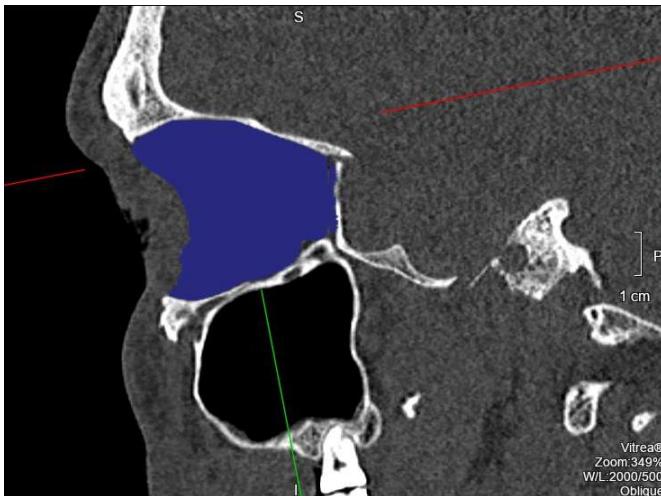


Рис. 7 а (Fig. 7 а)



Рис. 7 б (Fig. 7 в)

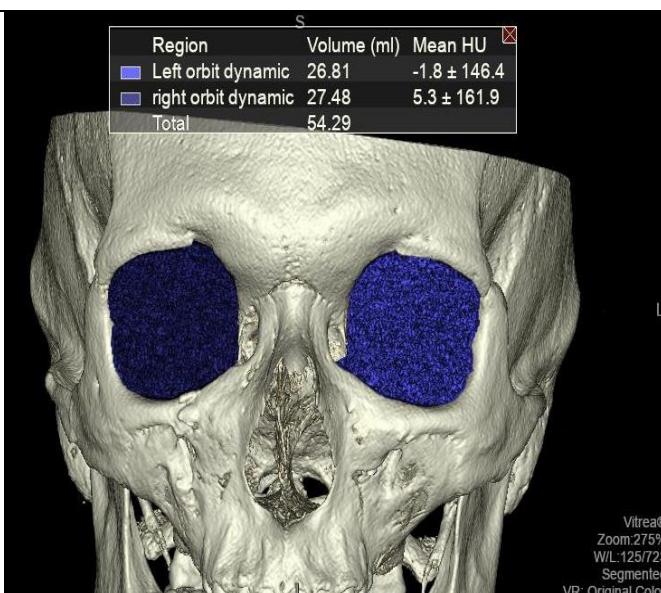


Рис. 7 в (Fig. 7 с)



Рис. 7 г (Fig. 7 д)

Fig. 7. MSCT, midface, bone window.

Orbital volume assessment according to MSCT data in a patient within 48 hours after trauma using workstation. The difference between the affected and normal orbits in the late posttraumatic period was 0,67 ml.

Рис. 7. МСКТ, средняя зона лица, костный режим. Измерение объёмов орбит после травмы на рабочей станции.

Измерение объёмов орбит через 2 года после травмы. В позднем посттравматическом периоде разница объёмов травмированной и здоровой стороны составила 0,67 мл.

The development of special postprocessing of the MSCT data gave the possibility to calculate pre-and postoperative orbital volume changes and present it in mathematical units (ml) in 3D mode. This method allows prediction of globe prolapse which is one of the most severe posttraumatic complication and often results in persistent functional impairment of visual apparatus. As the result the additional information can be acquired about condition of bony orbital structures in order to identify the risk of postoperative enophthalmos.

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It is our opinion that developed postprocessing of the MSCT data should be included in diagnostic protocol in every patient with orbital trauma within the preoperative planning, radiological dynamic control and assessment of surgical treatment.

Источник финансирования и конфликт интересов.

Авторы данной статьи подтвердили отсутствие финансовой поддержки исследования и конфликта интересов, о которых необходимо сообщить.

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