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КАФЕДРА ЧЕЛЮСТНО-ЛИЦЕВОЙ ХИРУРГИИ

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ПЕРЕЛОМЫ СКУЛОВОЙ КОСТИ, СКУЛО-ОРБИТАЛЬНОГО И СКУЛО-ВЕРХНЕЧЕЛЮСТНОГО КОМПЛЕКСОВ

FRACTURES OF ZYGOMATIC BONE, ZYGOMATIC-ORBITAL AND ZYGOMATIC-MAXILLARY COMPLEXES

Учебно-методическое пособие

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Отражены вопросы травматических повреждений скуловой кости, скуло-орбитального и скуло-верхнечелюстного комплексов.

Предназначено для студентов-стоматологов 4–5-го курсов медицинского факультета иностранных учащихся, врачей-интернов, клинических ординаторов, обучающихся на английском языке.

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MOTIVATIONAL CHARACTERISTICS OF THE TOPIC

Total Time: 225 minutes.

Purpose of the lesson: to study the clinic picture of injuries connected with the midface area bones, learn to diagnose them and make a plan of treatment depending on the type of injuries.

Objectives:

1. Examine the types, classification, clinical manifestations of bone injuries of the midface areas.
2. Learn to examine patients with midface trauma (fractures) and master the basic manual skills of clinical methods for its diagnosis.
3. Learn to interpret the data of radiation diagnosis taking into account the clinical manifestations of midface fractures (radiography, multyspiral computed tomography, cone-beam computed tomography).
4. Learn to plan the treatment process of patients with midface fractures.
5. Be familiar with basic up-to-date methods of surgical treatment of midface fractures, study indications for their application.

Requirements for the initial level of knowledge

To master the topic, it is necessary to revise the following material:

- anatomy of the midface bones, innervation and blood supply of the maxillofacial area;
- biomechanics of dental system;
- methods of radiation diagnosis, used for injuries of the craniomaxillofacial area;
- examination of the patient with surgical pathology of the face and neck.

Test questions from the related disciplines:

1. What are the main anatomical structures of blood supply and innervation of the maxillofacial area.
2. List the bones that form the midface area.
3. Specific features of the structure of the midface area bones.
4. Name the buttresses of the upper jaw; specify the force distribution over them.
5. List the methods of objective examination, used to diagnose the bone injures of the midface area.
6. List the methods of radiation diagnosis of the midface area bones.

Control questions:

1. Indicate the prevalence of bone injury in the midface area. Causes of midface fractures.
2. Give a classification of bone injures that form the midface area.
3. What are the clinical manifestations of midface fractures?
4. Give the definition of «combined trauma». Its connection with bone injures of the midface fracture.

5. What are the clinical examination methods of patients with midface fractures?

6. Specify additional methods of investigation in patients with midface fractures.

7. Describe an X-ray of the skull in the semi-axial projection with a fracture of zygomatic bone, zygomatic arch, zygomatic-orbital complex, zygomatic-maxillary complex.

8. Make a plan for treating a patient with midface fractures.

9. Determine the indications for closed reposition of zygomatic bone, as well as the indications for open reposition and osteosynthesis of mid-face bones.

10. List the methods of closed reposition of zygomatic bone.

11. List the methods of open reposition and osteosynthesis of mid-face bones.

12. Specify recommendations that patients should perform on an outpatient basis after surgical treatment of mid-face bones.

13. Clinical follow-up of patients after surgical treatment of mid-face bones.

PREVALENCE AND CAUSES OF MIDFACE FRACTURES.

Massive increase in the incidence of face fractures during last years as well as predominant injury to people of working age require the improvement of approaches for diagnosing traumatic injuries, surgical treatment and post-operative rehabilitation of patients. Fractures of zygomatic bone with displacement are accompanied by significant functional and aesthetic disturbances. Fractures of zygomatic bone are often accompanied by fractures of other facial bones.

Midface fractures often occur in men of the 21–30 age group. Another trend is an increase in the number of traumas due to alcohol.

Statistics shows high frequency of midface injuries and the severity of injuries that are rapidly becoming traumas of medium and high energy. Accidents are a cause of increasing injuries to the facial part of the skeleton. In case of an accident, the lower jaw and more often, the bones of the midface area are less likely to be damaged, compared with fights. Isolated fractures of the upper jaw occur infrequently in car accidents (11 % of cases) — and even less frequently in fights (4 % of cases). Fractures of the upper jaw by Le Fort are often caused by high energy. It is stated, that injuries due to car accidents or falls from height are high energy damages.

Midface fractures are often combined with brain damage and damage to other parts of the body. Combined craniocerebral lesions can be both fractures of all bones of the facial part of the skull and part of the combined trauma and accompanied by damage to the bones of the limbs, chest, intestines, and spine.

Combined craniocerebral trauma is the most severe example of damage that has to be treated by maxillofacial surgeons. The term «combined trauma» was adopted in 1975 at the Third All-Union Congress of traumatologists-orthopedists.

In case of a combined trauma, the patient is delivered to a specialized facility dealing with the most severe injuries. Large clinics often create the departments of combined injuries that specialize in the treatment of patients with combined trauma. Combined injury is characterized by the fact that the damage does not add up, and each damage potentiates the other.

In the general structure of disability, injuries hold the third place after cardiovascular and oncological diseases, with a special note of delayed disability in injuries.

Injuries are the main cause of death before the age of 40.

CLASSIFICATION OF MIDFACE FRACTURES

Classification of Knight and North, 1961:

Group 1. Zygomatic bone fracture line can be determined only on pictures. There is no displacement. No aesthetic deformities.

Group 2. Isolated zygomatic arch fracture. Lockjaw and cosmetic deformity are present.

Group 3. Fractures of zygomatic bone body without rotation.

Group 4. Zygomatic bone fractures with medial angle of body rotation.

Group 5. Fractures of the zygomatic bone with a lateral angle of body rotation. Very unstable fractures, which tend to give poor results with closed reduction.

Group 6. Complex fractures, in which multiple lines pass through the body of zygomatic bone. Treated with open reduction and fixation system of miniplates.

Classification of Manson, 1990, which divides the injury according to the type of energy, was found to be very useful. It is not the main one, but there is a clear relationship between the fractures of the zygomatic bone, zygomatic-orbital and zygomatic-maxillary complexes, depending on the energy of the trauma.

Classification of Manson, 1990:

− Damage of low energy: if zygomatic bone is damaged, there is a minimal displacement, or nothing at all.

− Damage of medium energy: fractures of the zygomatic bone are accompanied by damage to all supporting buttresses. Slight or medium displacement can be noted. For treating this fractures an open reposition is required.

− Damage of high energy: fractures are accompanied by injuries of the upper jaw. An open reposition is needed to treat this group of lesions with multiple fixation points.

Classification of Zingg, 1992:

Type A. There is a fracture of one buttress:

− subtype A1: fracture of zygomatic arch;

− subtype A2: fracture of the lateral wall of the orbit;

− subtype A3: fracture of the bottom wall of the orbit.

Type B. Fractures involving three buttresses are also called tripod fractures.

Type C. Splinter fractures with orbital involvement.

In case of A3, B, C fractures the bottom of the orbit cavity is damaged and the injury of soft tissue contents is possible.

Classification of fractures of the orbit of V. P. Nikolaenko, 2009:

- «Explosive» and depressed fractures of the bottom wall of the orbit;
- «Explosive» and depressed fractures of the inner wall of the orbit;
- Fractures of zygomatic complex;
- Nasoetmoiedal fractures;
- «Explosive» and depressed fractures of the upper wall of the orbit;
- Fronto-basal fractures (including Supraorbital, glabellar as well as isolated fractures of the upper margin of the orbit);
- fractures of the apex of the orbit, including concomitant damage to the optic nerve channel;
- local fractures caused by sharp objects.

Classification of fractures of the bottom wall of the orbit of A. S. Kiselyov, 2006:

- finely fragmented fractures;
- comminuted fractures;
- wing: In this case it's fragments don't lose contact with the bone and tend to return to its original position, compromising the soft tissue trapped between them.

Classification of fractures of the infraorbital canal of N. A. Savrasova, 2002:

- longitudinal;
- transverse;
- combined;
- multiple.

CLINICAL CRITERIA FOR FRACTURES OF THE ZYGOMATIC BONE, ZYGOMATIC-ORBITAL AND ZYGOMATIC-MAXILLARY COMPLEXES

If patients are suspected to have a bone fracture in the middle area of the face, than complaints, history of injuries, clinical examination and radiation diagnosis are collected. After that clinical diagnosis is made the prognosis is evaluated and the tactics of necessary treatment is established.

When examing patients with zygomatic bone fractures, zygomatic-orbital and zygomatic-maxillary complexes, following reasons for injuries are taken into account: domestic, industrial, criminal, car accident or falling from the height. The reason of the injury affects the methods of radiation examination, as well as necessity of consultation of related specialists. Particularly severe injuries are those obtained in an accident and falling from the height. In case of combined injuries,

treatment of maxillofacial area is provided after stabilization of the patients' condition on the basis of the examination in combined injuries and neurosurgical departments.

Statistically significant differences in causes of injury of patients with fractures of zygomatic bone and the zygomatic-maxillary complex have been revealed; patients with fractures of zygomatic-orbital and zygomatic-maxillary complexes (table 1) (Thesis for the degree of Candidate of Medical Sciences, Pavlov O. M. «Differential diagnosis and treatment tactics for fractures of the zygomatic bone, zygomatic-orbital and zygomatic-maxillary complexes».)

Table 1

The frequency of causes of injury in patients with fractures of the zygomatic bone, zygomatic-orbital and zygomatic-maxillary complexes

Causes of injuries	Fractures of the zygomatic bone, %	Fractures of the zygomatic-orbital complex, %	Fractures zygomatic-maxillary complex, %	Total, %
Household	75 (68,81)	27 (24,77)	7 (6,42)	109 (100)
Attack	46 (64,79)	22 (30,99)	3 (4,23)	71 (100)
Road accident	5 (35,71)	5 (35,71)	4 (28,57)	14 (100)
Industrial injury	4 (50,00)	1 (12,50)	3 (37,50)	8 (100)
No data	12 (50,00)	8 (33,33)	4 (16,67)	24 (100)

Note: * $\chi 21–3 = 50,82$; $p < 0,05$;
$\chi 22–3 = 53,18$; $p < 0,05$

In assessing the patient's complaints, much attention is drawn to the presence of pain in the area of nasal bones, jaw, orbit, zygomatic bone, soft tissue structures of the face; Changes in the bite; Presence of areas of impaired sensation on the face; Nosebleed; double vision.

During a clinical examination, first of all attention is paid to the symmetry of zygomatic bones location, the presence of collateral edema and post-traumatic hematomas, the bone stairs along the lower margin of the orbit, zygomatic arch, zygomatic-alveolar crest and zygomatic-frontal suture, pain on palpation of the bone contour in the orbit, upper jaw, nasal bones, impaired function. In the presence of pronounced collateral edema, it is often difficult to determine the presence of bone «stairs» during palpation. Fractures of the upper jaw cause significantly more swelling and bruising than isolated damage of the zygomatic bone or the bones of the nose. Often, the severity of fractures of bones of the midface area of the face externally manifest similarly, and the degree of severity of collateral edema and post-traumatic hematomas does not correlate with the severity of the existing lesions (*fig. 1, 2*).

Fig. 1. Patient with a fracture of lower orbital wall left side, multiple face hematomas

Fig. 2. Patient with CCT moderate severity; fracture zygomatic-maxillary complex right side; fracture Le Fort II left side; fracture naso-orbito-ethmoidal complex; fracture of the frontal bone

In case of paroorbital hematomas the face of the patient looks like panda's face with big eyes. Nasal bleeding can start suddenly and become a serious problem in this group of patients. An important step in ensuring patient stability is the stopping of bleeding.

It is necessary to differentiate bleeding from the maxillofacial area from the cerebrospinal fluid, which can be in the form of rhinorrhea or otorrhea. Rhinorrhea and otorrhea occur in multiple or panfascial fractures. Fractures of the upper jaw cause flattening in the form of a «dish-like» face. The displacement of the upper jaw back and forth causes premature contact in posterior teeth and an open bite in front, what causes lengthening of the face. While percussion of the teeth of the upper jaw on the side of the fracture, the symptom of the «cracked pot» is determined.

Fractures of nasal bones are often combined with multiple fractures of facial bones.

THE DIFFERENTIAL DIAGNOSIS OF PATIENTS WITH FRACTURES OF ZYGOMATIC BONES, ZYGOMATIC-ORBITAL AND ZYGOMATIC-MAXILLARY COMPLEXES

When diagnosing patients with midface fractures, the anatomical structure of the area should be taken into account. An important component of the facial midface area is the orbit. Recently, more and more often not only fractures of the zygomatic bone or upper jaw are diagnosed, but also the complexes that are damaged by traumas, — fractures of the zygomatic-orbital complex, fractures of the zygomatic-maxillary complex, fractures of the zygomatic complex itself.

The orbit is formed by 7 bones that form a pyramid shaped upward and posteriorly: the zygomatic bone, the upper jaw, the frontal bone, the large and small wings of the sphenoid bone, the orbital process of the palatine bone, lecrimal bone, the orbital process of the latticed bone.

The lower and medial walls of the orbit are thin bone plates. Fractures of these walls are difficult to assess when carrying out radiography in standard projections. An important factor in planning treatment is the position of the lateral cantus, which is located 10 mm below the zygomatic-frontal suture and 2–4 mm inward from the lateral margin.

Rotation of the body of zygomatic bone, especially with the displacement of the lateral wall of the orbit, increases the volume of the orbit and is a frequent cause of enophthalmos.

The zygomatic bone is attached to the skull in 4 places. Fractures at the side of one joint with a displacement are accompanied by fractures in other places of junction of the zygomatic bone. It is noted that various energy traumas can lead to different types of bone fractures in the midface area of the face involving a zygomatic bone, fractures of the zygomatic bone without displacement in low-energy injuries to multiple disintegrations of the entire midface area of the face in high-energy injuries.

In fractures involving the zygomatic bone the following symptoms are observed:

1) impaired of sensitivity in the area of innervation of the second branch of the trigeminal nerve: numbness of the cheek, nose, upper lip, alveolar process on the side of the lesion.

2) flattening of the face in the affected side,

3) impaired vision, especially in the form of diplopia,

4) hematomas along the orbit area,

5) edema in the orbit area,

6) subconjunctival hemorrhages,

7) limited movement of the eyeball,

8) changes in pupillary reflexes,

9) limited mouth opening,

10) hematomas in buccal area,

11) enophthalmos,

12) restriction of mobility of the lower jaw.

In fractures of zygoma, the most common clinical signs are:

1) collateral edema in the orbit, midface area,

2) post-traumatic hematomas of the infraorbital region,

3) subconjunctival hemorrhages,

4) flattening of the face,

5) the symptoms of the step along the lower margin of the orbit and / or the zygomatic-alveolar crest, and / or zygomatic-frontal suture, and / or the zygomatic arch,

6) neuropathy in the area of innervation of the second branch of the trigeminal nerve, which passes independently in 3–5 days after receiving the trauma.

Fractures of the zygomatic-orbital complex refer to fractures of medium energy. In clinical examination of fractures of the zygomatic-orbital complex in addition to the symptoms of fractures of the zygomatic bone, the following symptoms are revealed:

1) diplopia,

2) external or internal ophthalmoplegia,

3) persistent sensitivity disorders in the area of innervation of the second branch of the trigeminal nerve, which were not stopped without surgical treatment.

The presence of severe posttraumatic collateral swelling and bruising often makes it difficult to determine the bone stairs in the area of the orbit and zygomatic bone. In fractures of the zygomatic-orbital complex, the presence of bone stairs in the area junctions of the zygomatic bone with the adjacent bones is characteristic. On clinical examination bone stitches are defined along the lower margin of the orbit, zygomatic-frontal suture, zygomatic-alveolar crest, zygomatic arch.

Fractures of zygomatic-maxillary complex are high-energy fractures. In zygomatic-maxillary complex fractures there are difficulties in identifying all clinical signs, the patient with this type of damage usually gets moderate or severe

CCT and combined trauma. It requires installation of endotracheal tube for mechanical ventilation, nasogastric tube for feeding the patients. In this type of damage multiple impairments of the bone contour of the face in the area of the orbit, zygomatic bone, zygomatic arch are observed. When attempting to move the upper jaw is determined by its mobility on Le Fort I, II or III. Availability of sedation makes it impossible to assess visual function and disorders of the sensitivity of II branch of the trigeminal nerve, due to the lack of awareness or a violation of its level.

X-RAY METHODS OF EXAMINATION IN CASES OF FRACTURES OF THE MIDFACE BONES

Clinical examination is not sufficient for the diagnosis of bone fractures in the midface area of the face, and it is necessary to use X-ray examination methods:

1. Radiography.
2. Multispiral computed tomography.
3. Cone-beam computer tomography.

Planar radiography is an acceptable diagnostic method that can reviel the presence of a serious injury to the midface area. However, X-ray diffraction in standard projections is often insufficient to determine the damage. Damage of the cervical spine is a contraindication for X-rays.

Performing X-ray in a semi-axial and axial projection can significantly worsen the prognosis of cervical spine trauma. If the patient is suspected to have a TBI or a fracture of the cervical spine, MSCT should be performed initially. MSCT is useful for suspected craniocerebral trauma or fractures of the skull base bones, when the radiography shows no signs of damage.

When analyzing fractures of the bones of the midface area and after the examination by the methods of CBCT and MSCT, we developed diagnostic criteria that allow to include fractures to injuries of the zygomatic bone, zygomatic-orbital and zygomatic-maxillary complexes (Glinnik A. V., Pavlov O. M.):

1. In fractures of the zygomatic bone, fracture lines pass through the zygomatic-alveolar crest; through the lower margin of the orbit — lateral to the zygomatic-maxillary suture; in the area of the zygomatic arch — medial to the zygomatic-temporal suture; in the area of the lateral margin of the orbit — along zygomatic-frontal suture; in the field of the zygomatic-sphenoidal suture. The displacement of bone fragments is minimal or absent in the area of the zygomatic-frontal and zygomatic-sphenoidal sutures, moderate in the area of the lower margin of the orbit and zygomatic-alveolar crest, moderate or minimal in the area of the zygomatic arch. There are injuries to the anterior and posterior walls of the maxillary sinus. The bone fragment of the zygomatic bone body does not form small fragments, there may be an additional fracture line through the body of the zygomatic bone (*fig. 3, 4*).

Fig. 3. Fracture of zygomatic bone right side. 3D-model MSCT

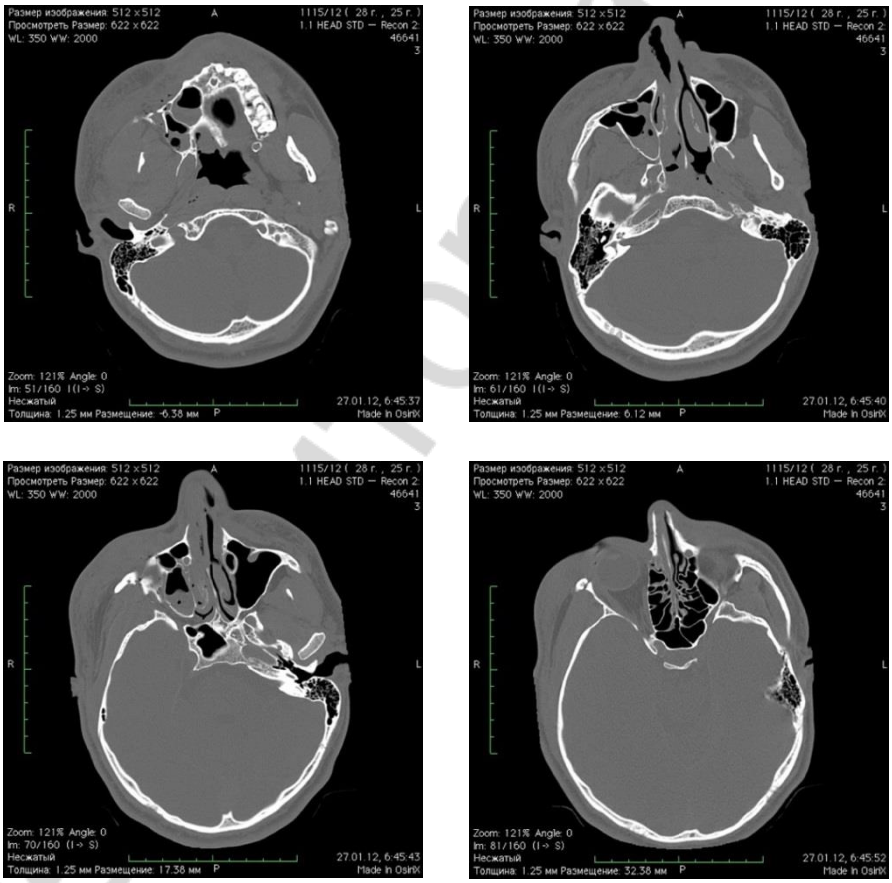

Fig. 4. Fracture of zygomatic bone right side. Axial projection of MSCT

2. In fractures of the zygomatic-orbital complex, fracture lines pass through the zygomatic-alveolar crest — often at the base in the area of the alveolar process of the maxilla; through the lower margin of the orbit — in the area of the zygo-

matic-maxillary suture or medial; in the area of the zygomatic arch — along the zygomatic-temporal suture or near it; in the area of the lateral margin of the orbit — along zygomatic-frontal suture. The displacement of the bone fragments is moderate in the area of the zygomatic-frontal and zygomatic-sphenoidal sutures, moderate or pronounced in the area of the lower margin of the orbit and the zygomatic-alveolar crest, moderate in the zygomatic arch area, over the zygomatic-temporal suture. There are pronounced injuries to the anterior and posterior walls of the maxillary sinus. The bone fragment of the zygomatic-orbital complex does not form small fragments (*fig. 5, 6*).

3. In fractures of the zygomatic-maxillary complex, fracture lines pass through the zygomatic-alveolar crest. There may be several fracture lines along the zygomatic-alveolar crest; through the alveolar process of the upper jaw. The fracture lines can be both horizontal (in the area of the frontal process of the upper jaw) and sagittal (through the hard palate); the lower margin of the orbit — medial to the zygomatic-maxillary suture. There may be several fracture lines with the formation of fragments of the lower margin of the orbit; in the area of the zygomatic arch — distal to the skull-shaped suture. There may be several fracture lines in the zygomatic arch with the formation of a number of bone fragments; in the region of the lateral margin of the orbit — along the zygomatic-frontal suture or above it; in the field of the zygomatic-sphenoidal suture. Displacement of bone fragments expressed in the area of the zygomatic-frontal, zygomatic-sphenoidal sutures, zygomatic-alveolar crest, the lower margin of the orbit, moderate in the zygomatic arch. There is a small fracture of the anterior and posterior walls of the maxillary sinus, the body of the zygomatic bone, the upper jaw (*fig. 7, 8*).

The use of the developed diagnostic criteria facilitates the description of trauma in one of the three types of fractures.

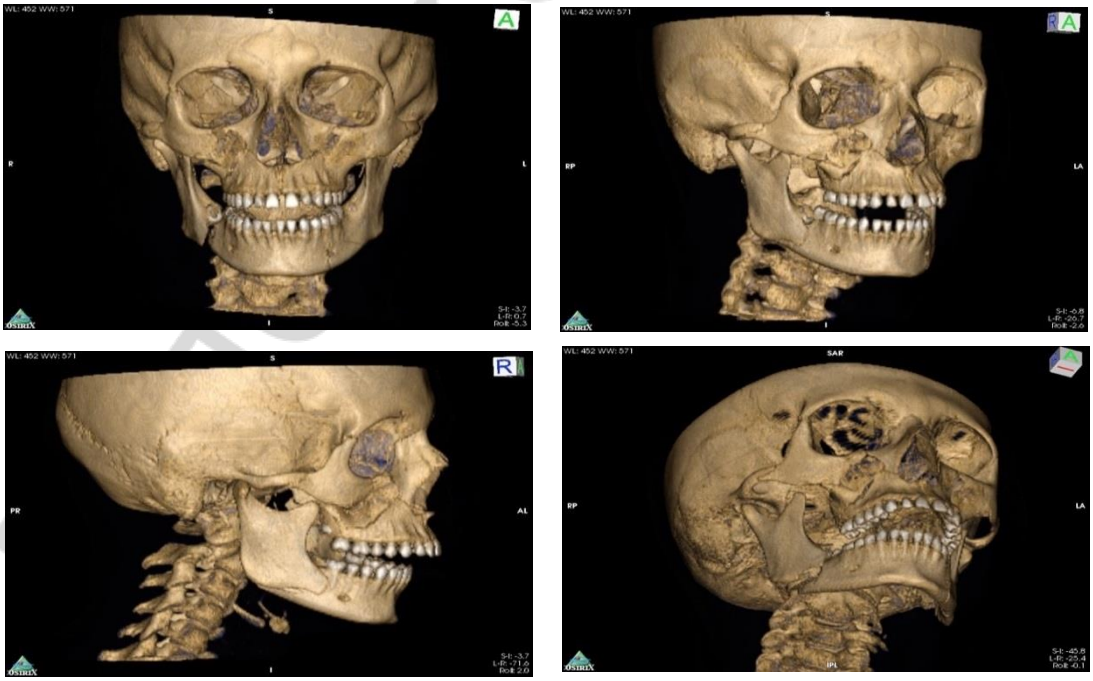

Fig. 5. Fracture of zygomatic-orbital complex right side. 3D-model MSCT

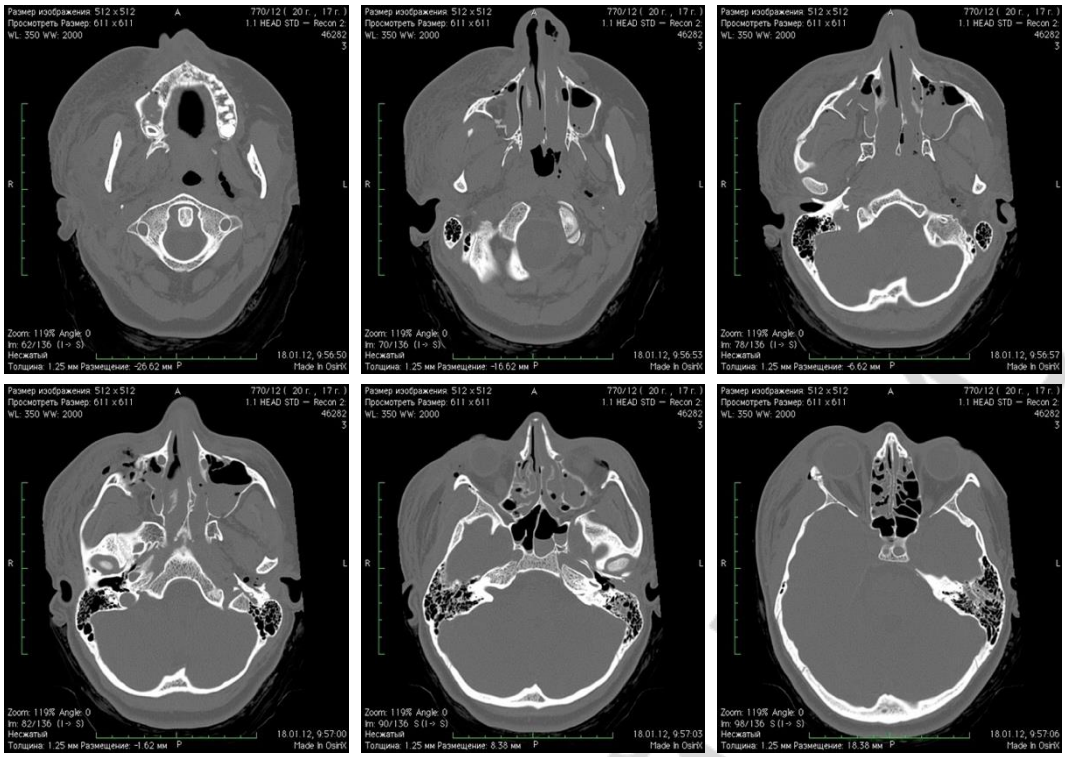

Fig. 6. Fracture of zygomatic-orbital complex right side. Axial projection of MSCT

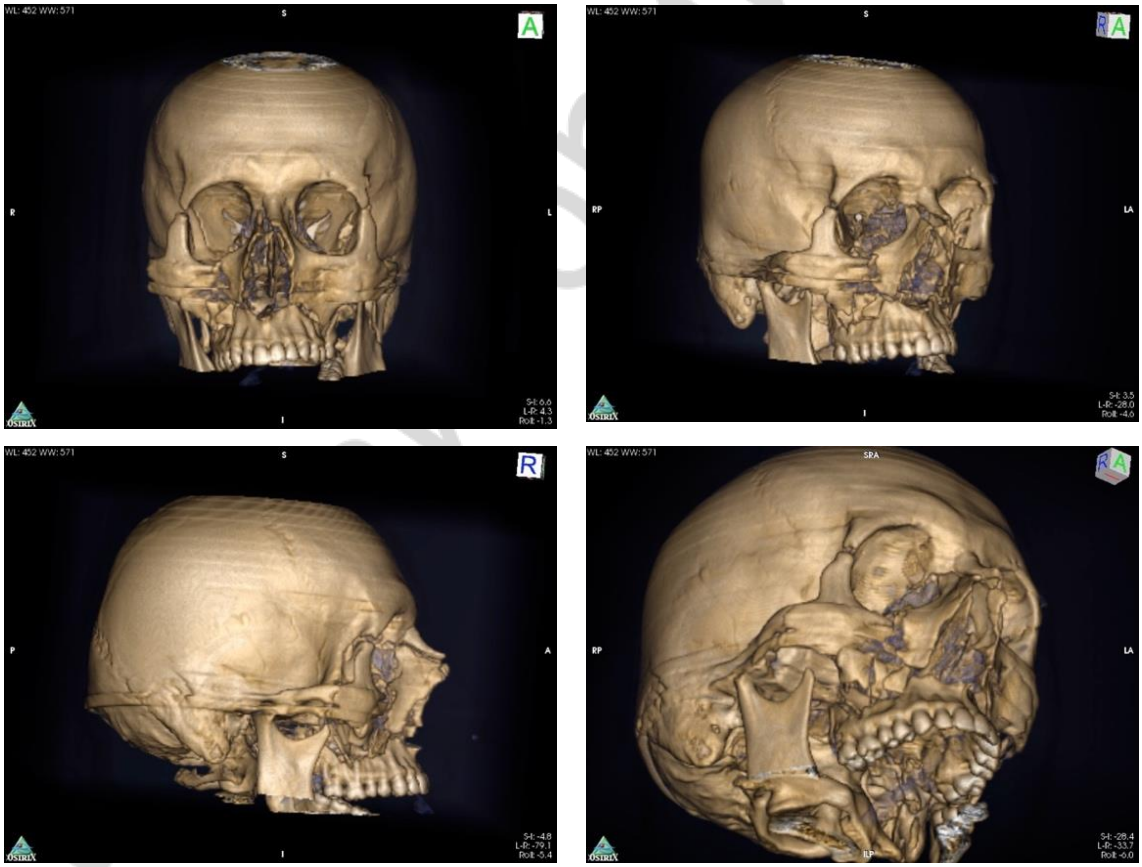

Fig. 7. Fracture of zygomatic-maxillary complex right side. 3D-model MSCT

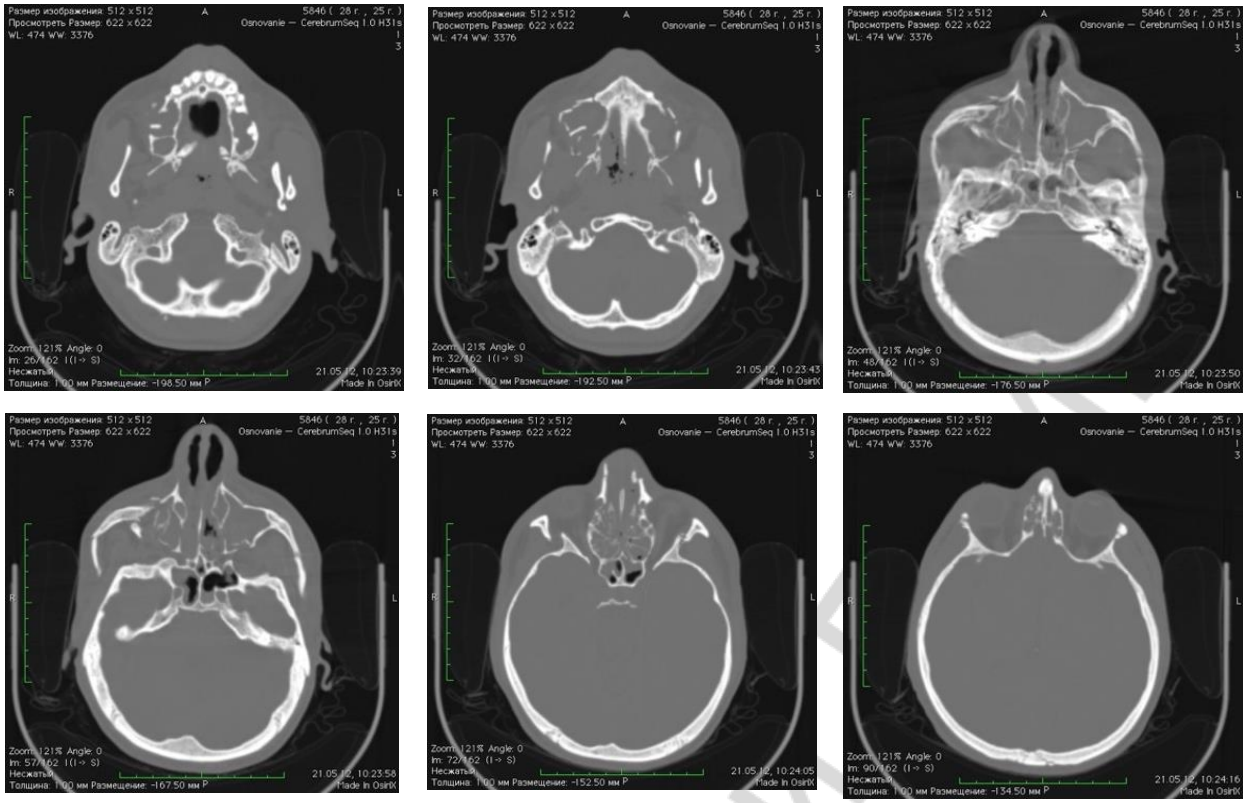

Fig. 8. Fracture of zygomatic-maxillary complex right side. Axial projection of MSCT

TREATMENT OF MIDFACE FRACTURES

Before treating patients with zygomatic bone fractures, zygomatic-orbital and zygomatic-maxillary complexes the condition of patients should be improved. Damage of the brain and ophthalmic damage are paramount in terms of providing medical care. It is necessary to perform primary surgical treatment and wound suturing, if existing wounds are not required for access with open reposition of bones of the midface. Specialized surgical treatment is advisable to perform even when the patient is in the intensive care unit, since the fractures of bones of the midface tend to consolidate faster than other fractures.

If the patient has indications for drainage of intracranial hematomas, it is advisable to have a maxillofacial surgeon to assess the existing damage. If possible the doctor chooses access in such a way that the reposition of the bones of the facial skeleton can be carried out completely.

Penetrating wounds of the eyeball are primary damages among all craniofacial injuries requiring surgical treatment, except those that threaten life. It is justified to postpone assistance for eyeball damage only in case of transportation of the patient to a specialized center, where this assistance will be rendered at a higher professional level, that is, in the ophthalmological department of hospitals.

All described methods of treatment of zygomatic bone fractures, zygomatic-orbital and the zygomatic-maxillary complexes can be divided into methods of closed and open reduction.

Fractures of the zygomatic bone without displacement do not require surgical treatment.

While carrying out the reposition of the fractures of the zygomatic bone, zygomatic-orbital and the zygomatic-maxillary complexes general anesthesia is used. There are methods of treating fractures using local anesthesia when performing not only a closed reposition of the zygomatic arch, but also a closed or open reposition of the zygoma. Conductive anesthesia in the area of the maxillary nerve on the side of the lesion in combination with local infiltration anesthesia in the areas along the reposition and fixation gives anesthesia for 90-120 minutes. Using 1% solution of lidocaine with adrenaline in dilution of 1: 80,000 also provides satisfactory anesthesia. In assessing the stability of the patient general anesthesia has high risks carring out. The use of local anesthesia in these cases is an appropriate alternative while rapid reposition and fixation.

When carrying out a closed reposition a number of authors indicate the desire to anchor bone fragments to a stable position without performing osteosynthesis using mini or microplate systems. The method of repositioning the zygomatic bone through a tiny incisions in the cheek area which is widely used nowadays was suggested by Strohmeyer, 1844. Although the closed repositioning method has a sufficient number of disadvantages and does not allow zygomatic bone to harden of the after the reposition, it is very common. The use of reponators in the form of a hook, such as the Limberg hook, for repositioning, is a simple and unexpensive method of assisting, especially in patients with isolated fractures of the zygomatic arch.

An alternative to this method is to carry out a closed reposition by the 3D-CR method (Glinnik A. V., Pavlov O. M.)

The 3D-CR method provides a significant advantage in the positioning of the zygomatic bone, but it also requires a longer surgical procedure, which requires the use of endotracheal anesthesia. It is sufficient to conduct intravenous anesthesia while repositioning by Limberg hook because of the short operation time.

In case of doubtful fractures of the zygomatic bone, which may require open reposition, it is advisable to begin repositioning using the 3D-CR method, because the patient will initially be under endotracheal anesthesia.

Development and implementation of the 3D-CR method in clinical practice was associated with the limitation of the possibility of precise reposition of the zygomatic body of the zygomatic bone using the traditional technique of closed reposition with the Limberg hook.

Carrying out the method of 3D-CR:

1. Point section 3–5 mm in the area of intersection of vertical line through the outer margin of the orbit and a horizontal line through the lower nasal spine;
2. Insert Limberg hook into the wound and carry out primary reposition of zygomatic bone body in a position that reduces the displacement of the body of the zygomatic bone medially, downward, backward; this manipulation is neces-

sary to reduce the number of displaced soft tissue structures in the area of the lower margin of the orbit and zygomatic bone body directly over the bone contour;

3. Tiny incision 3–5 mm at the intersection of a vertical line through the outer margin of the orbit and the horizontal line through the lower margin of the orbit;

4. Point through the incision via mosquito stratified structure of soft tissue to the bone;

5. Burr hole is created in the bone at dilution of the surrounding soft tissue structures using hemostat instrument;

6. The tool for repositioning rigid [resembling the shape of a tap, which is used for threading the screws to threaded with nonaggressive in the system miniplates] is inserted into the burr hole;

7. Rigid fixation of the instrument in the body of the zygomatic bone by screwing it;

8. It is carried out by positioning the zygomatic bone body in three dimensions;

9. If reposition is blocked due to the presence of fragments, additional force may be applied with a Limberg hook;

10. Using the method of 3D-CR for positioning in case of open reposition further fixation of bone fragments is done with the help mini-plate system;

11. Tool for reposition is removed from the bone by twisting it;

12. Wound is closed with stitches.

Advantages of 3D-CR method:

− rigid fixation in the body of the zygomatic bone, which prevents the tool from moving during the closed reposition;

− low traumatism;

− the possibility of an accurate linear displacement of the body of the zygomatic bone in 3 planes;

− the possibility of accurate and predictable changes in the angle of rotation of the zygomatic bone body;

− reduction of deformations after closed reposition;

− reduction of the need for secondary corrective surgeries;

− extraoral positioning does not prevent osteosynthesis, especially intraoral, using the 3D-CR method as a method of positioning the zygomatic bone, the zygomatic-orbital and zygomatic-maxillary complexes when performing open reposition and osteosynthesis.

Disadvantages of 3D-CR method:

− longer time in comparison with the classical reposition with the help of the Limberg hook;

− the need for endotracheal anesthesia;

− requires more technical training than the closed reposition with the help of Limberg hook;

− requires more professional training of the surgeon.

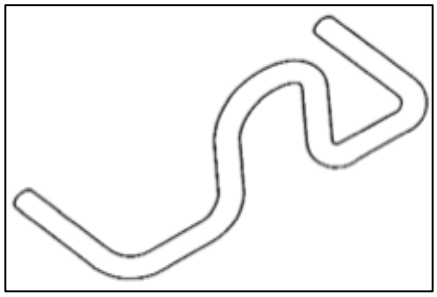

Fig. 9. Fixation device in zygomatic fractures

Some authors suggest the manufacture of the instrument from the Kirschner knitting needle, which is a U-shaped brace with two intraosteal elements and a corrective loop made on the staple crossbar (*fig. 9*).

The use of spokes to secure bone fragments, although relatively simple in performance, does not give the necessary degree of visualization for fractures of zygomatic bone before fixation. This method has disadvantages: closed reposition is performed not by visualization of fracture lines, but with the help of palpating the boundaries of the bone contour restoration, and fixation by the needle is carried out on the same anatomical landmarks, which in case of incomplete closed reposition or mistakes in its conduct can lead to incorrect fixation. Number of authors suggest improving the fixation of bone fragments after reposition by using techniques of fixing the zygomatic bone with the help of struts of its own production along the alveolar crest or the zygomatic-frontale suture. The method does not require complicated adaptations, but at the same time it does not eliminate the possibility of rotational displacements of zygomatic bone and the zygomatic-orbital complex, which can lead to secondary postoperative deformations.

Interposition of soft tissues in the area of fracture lines, comminuted fractures, and unstable fractures make closed reposition untenable and may require an ***open reposition***. Some authors note that they abandoned the methods of closed repositioning at fractures of zygomatic complex due to unsatisfactory aesthetic results. Also, when the reposition is closed, it is not always possible to restore the volume of the orbit, what can lead to unsatisfactory aesthetic and functional results. Restoration of the former volume of orbit is an important criteria for assessing the quality of reposition and preventing the development of enophthalmos after surgical treatment.

Untill present open reposition of the zygomatic bone and the zygomatic-orbital complex was combined with the tight tamponade of the maxillary sinus to hold the bone fragments in anatomically correct position. The use of this method has indications and is often used in small-fragment fractures. This method of treatment can lead to the development of infectious and inflammatory complications, secondary displacement of bone fragments and formation of scars, disoder of maxillary sinus ventilation, lack of precise comparison of bone fragments and, consequently, postoperative deformations. Fixation of bone fragments with iodoform swab is not tight, the swab has the property of increasing in size when impregnated with blood, that leads to changes in the position of the bone fragments, a decrease in the orbital volume, that in turn leads to exophthalmos.

One of the most universal and convenient methods of fixing fractures is rigid fixation with the help of mini-plates.

A special feature of the treatment of fractures of zygomatic bone, zygomatic-orbital and zygomatic-maxillary complexes is that fixation of the bones should be performed on buttresses.

Two vertical buttresses — lateral and medial maxillary and 1 horizontal buttress — the upper transverse maxillary pass through the middle zone of the face (*fig. 10*). Stability of fixation is achieved by carrying out a three-point fixation, but several authors note that the blood supply for bone fragments worsens.

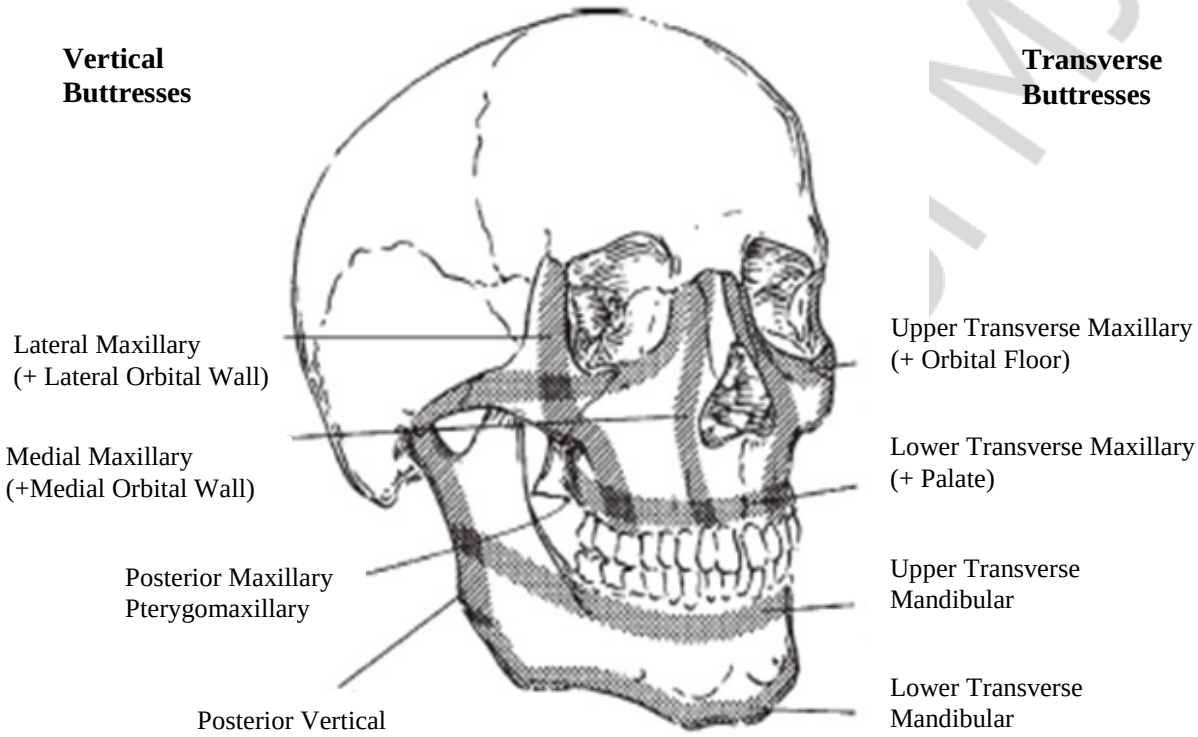

Fig. 10. Buttresses of facial bones (according to Hopper)

When fixing fractures, the main condition is to ensure the stability of bone fragments. Unstable fixation leads to lack of fractures consolidation, as well as the presence of inflammatory complications. The presence of stable fixation of bone fragments and tight contact between them allows to achieve the formation of primary bone adhesion, which goes without formation of connective tissue capsule. Micro mobility of bone fragments after fixation leads to fusion through the bone callus.

The use of mini- or microplates in fixing fractures excludes rotational displacement of bone fragments. When fixing with a wire suture at 2 points, rotation in the area of the zygomatic arch can occur, that is not the case when fixing the mini-plates.

While planning the types and methods of surgical access, different authors don't use unified approaches to the number of necessary fixation points. Fixation at one point is used quite often, but the advantages of 2- or 3-point fixation should

be noticed. Zygomatic bone tends to secondary displacement under the influence of the masticatory forces even after fixation. When fixing the fractures of zygomatic bone, zygomatic-orbital and zygomatic-maxillary complexes, 2-point fixation is sufficient for most patients.

Advantages of fixation points were determined by T. Nagasao and other doctors the zygomatic bone was alternately fixed in the area of zygomatic-frontal suture, the zygomatic-alveolar crest and the lower margin of the orbit with mini-plates on 2 screws on each bone fragments, then a force of 10 kg was applied to the zygomatic bone, after which the displacement of the central point of the body of the zygomatic bone (P) was evaluated.

As a result of their experiment, the smallest displacement of the central point of the body of the zygomatic bone (P) was observed with fixation along zygomatic-frontal suture, and the largest displacement — with fixation along the lower margin of the orbit.

To eliminate deformations and ensure a stable fixation of fractures, it is necessary to use rigid fixation in several planes, while a larger fixation area provides a more stable result (*fig. 11*).

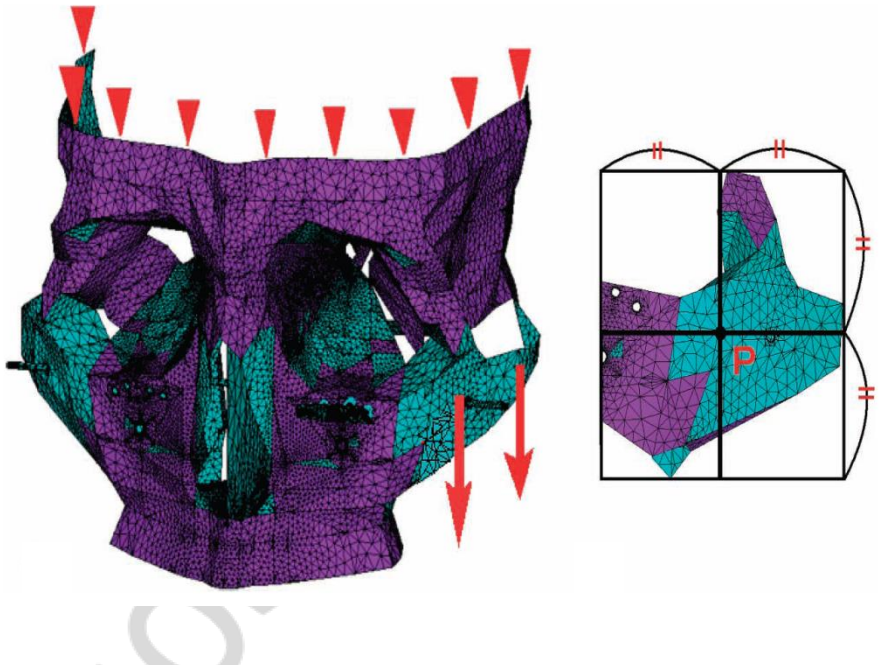

Fig. 11. The experiment of T. Nagasao et al. on the evaluation of the displacement of the central point of body the zygomatic bone (P) under influence of a vertical force downward

Although Davidson and others analyzed the methods of the most stable postoperative fixation, it was shown that it is achieved by performing osteosynthesis with mini-plates or a wire suture along zygomatic-frontal suture, zygomatic-alveolar crest and lower margin of the orbit. The presence of 3-point fixation by carrying out osteosynthesis with the help of wire-suture joints does not always give the necessary rigidity and stability in bone fractures treatment in the midface. The load even in 20 kPa leads to the weakening of fixation of bone fragments with

the help of osteosynthesis method using wire sutures. Based on the principle of stability of fixation of bone fragments, the use of wire sutures today should be as historical interest and should be used only in emergency cases when there is no physical presence of mini or microplate systems in non-specialized departments with simultaneous surgery.

Carrying out open reposition and fixation of the zygomatic bone requires the use of zygomatic-frontal suture, zygomatic-alveolar crest. It is necessary to apply a mini-plate with fixation on 4 screws on zygomatic-frontal suture.

At the same time, carrying out open reposition requires the use of hard fixation of bone fragments with the help of system of mini-plates 1 mm thick and screws 5–19 mm in length.

Carrying out intraoral reposition of zygomatic bone, even as an initial method, reduces the quality of the primary reposition, since it is common knowledge that zygomatic bone is shifted usually down, inside and back, and for the correct position, pulling forces should be directed in the opposite direction along the displacement axis. The use of intraoral access for primary positioning often does not provide an opportunity to provide extension of the body of zygomatic bone along the axis of displacement.

Carrying out open reposition requires fixing zygomatic bone to eliminate its displacement along the vertical or horizontal lines. In clinical practice, eliminating horizontal displacement is uninformative and time-consuming. It is simpler and more effective to eliminate the displacement of the body of the zygomatic bone vertically with fixation along zygomatic-frontal suture.

After the reposition and fixation of the zygomatic bone, the strength of the chewing muscles can lead to the displacement of the bone fragments to the wrong position. The use of fixing structures from material restoring its original form has an advantage over standard mini-plate systems. Insufficient number of fixation points in the treatment of fractures of the zygomatic bone, zygomatic-orbital and zygomatic-maxillary complexes can lead to deformation of fixation structure. The use of microplates requires a number of fixation points to give higher stability to the fractures of the zygomatic bone, zygomatic-orbital and zygomatic-maxillary complexes. To replace posttraumatic bone defects in the midface area, various methods of closing defects can be used. Removal of small bone fragments from the maxillary sinus, crushed soft tissues, elimination of the interposition of soft tissues and decompression of the infraorbital nerve is a preventive measure for the development of infectious complications. Currently, ***titanium mesh plates*** are often used to cover bone defects, which are simple to use and allow to close complex defects. The use of titanium mesh plates, which have standard sizes of 10 × 10 cm or 12 × 12 cm, allows covering a defect of any extent and shape in the area of the midface. Anatomical structure of the midface especially junction of the zygomatic bone with other skull bones, makes the perioperative modeling of the necessary titanium implant fragment laborious. The use of stereolithography allows to accelerate the process of creating the necessary form, reduces the time of

operation, and also reduces the perioperative trauma associated with the permanent perioperative fit of the structure with the creation of the necessary dimensions and shape of the mesh titanium implant. In severe orbital injuries, implants made with the help of a stereolithographic model can significantly improve the quality of surgical care. Restoring the volume of the orbit with simultaneous reposition of the zygomatic bone or the zygomatic-orbital complex is an extremely important stage in planning surgical treatment. Control of reposition zygomatic bones, zygomatic-orbital-maxillary complexes by zygomatic-sphenoidal suture is an important step in assessing the quality of fixation of this type of injury.

For the fractures of the lower wall of the orbit simple reposition is insufficient and it is necessary to use different types of implants or grafts. It is noted that the defects of the lower and medial walls of the orbit more than 1 cm^2 require closure with the restoration of the volume of the orbit. The use of implants or bone grafts for the plastic repair of orbital defects in the future does not require their removal. To cover defects of the lower wall of the orbit and the anterior wall of the maxillary sinus, titanium mesh plates are actively used. A new interesting method of closing the defect of the anterior wall of the maxillary sinus is the use of disks of Ni-Ti alloys with 0,2–0,5 mm thickness. Postoperative atrophy of fatty tissue of the orbit is not a significant cause of postoperative enophthalmic development, in contrast to incomplete recovery of the orbit volume. Usually in extensive defects of the facial and cranial department individual implants of entire anatomical areas by CAD / CAM-technology are produce. An alternative method for reposition of the lower wall of the orbit is to perform open surgery on maxillary sinus, reposition of the lower wall of the orbit and tight transantral iodoform swabing of maxillary sinus, one end of which is displayed in the lower nasal passage formed through the anastomosis with maxillary sinus. Using iodoform swab for reposition of the bottom wall and the lower margin of the orbit has the same drawbacks as its use for fixing bone fragments of zygomatic bone and zygomatic-orbital complex, and currently must be limited.

It is noted that after the operation there are retrobulbar hemorrhages that require immediate treatment. The use of sinus swabing method significantly increases the degree of pressure on eyeball, and in the presence of retrobulbar hematomas may worsen the prognosis for vision. Thus, the use for filling the volume of the maxillary sinus materials tightly, particularly in case of hemorrhage, which also have the property of unpredictable increase in size while in the cavity of the maxillary sinus. It requires re-evaluation and control of functions and positions of the eyeball.

When swabing the maxillary sinus, exophthalmos and dislocation of the eyeball may be noted; this causes diplopia and requires decrease in the length of the tampon by partial extraction from the maxillary sinus cavity.

In absence of visual improvement or, conversely, impaired vision in the dynamics after surgery, despite the appointment of complex decongestion therapy,

decompression of orbit is required, which again raises the question about advisability of using the methods of tamponizing the maxillary sinuses.

Fracture of sinus walls with a slight displacement of bone fragments is not an indication for the operation on the maxillary sinus. The usefulness and convenience of using endoscopic control methods is indicated. It improves the visualization of content in the paranasal sinuses, especially for the maxillary sinus, and also indirectly lead to less access with open repositions, especially cuts in lengths due to better visualization during repositioning. The use of endoscopic technique allows one-time to clean the maxillary sinus. When performing open reposition, it is necessary to remove small free-standing bone fragments that can be necrotic.

Points of fixation of bone fractures in the midface area:

1) When performing open reposition and osteosynthesis of zygomatic bone, it is preferable to use a lateral maxillary buttress with a fixation point in zygomatic-alveolar crest area; in fracture of zygomatic bone complicated by additional fracture lines, it is also preferable to use a fixation along the upper transverse buttress with fixation along the zygomatic-frontal suture and the body of the zygomatic bone.

2) When fracturing the zygomatic-orbital complex, it is preferable to use both the lateral maxillary buttress with fixation points along zygomatic-alveolar crest and the zygomatic-frontal suture, as well as the combination of the lateral maxillary buttress with the upper transverse buttress with a 3-point fixation — along the zygomatic-alveolar crest, the zygomatic-frontal suture and the zygomatic arch or the lower margin of the orbit.

3) For fractures of the zygomatic-maxillary complex, fixation should be carried out at a minimum of 2 buttresses. It is preferable to use vertical buttress — the medial and lateral maxillary with fixation points along zygomatic-frontal suture, the zygomatic-alveolar crest, in the region of the frontal process of the maxilla. In some cases, additional fixation may be required along the horizontal buttress — the upper maxillary buttress, in the area of the zygomatic arch or the lower margin of the orbit.

To provide surgical approaches, ***subciliary, intraoral cuts or a section along the upper eyebrow*** can be used.

When subciliatory incision is made, it is receded 2 mm from the ciliary margin of the lower eyelid. Subciliary section is most often used when accessing the bottom wall of orbit. When performing reconstruction of zygomatic bone with individual titanium implants, it is sufficient to use an intraoral cut for their installation.

Performing *access by Dingman*, which consists of carrying out 2 incisions — one under the eyebrow for access to the zygomatic-frontal suture and the second, ciliary section, — gives a good revision of the lower margin of the orbit and the lateral margin of the orbit. Carrying out transconjunctival cut reduces the risk of post-operative removal of the lower eyelid associated with the cutaneous incision and improves aesthetic result.

The transconjunctival incision was described by Bourguet in 1924, and 50 years later Trnzel and Miller proposed this access for the treatment of small fractures in the bottom of the orbit. The presence of fractures of the upper jaw, which always occur in fractures of the zygomatic-maxillary complex, requires the use of bimaxillar splinting as the initial stage of closed reposition of bone fragments. When it is immobilization using bimaxillar splinting, secondary consolidation of bones occurs.

Duration of more than 3 months after a trauma in the midface area requires preliminary osteotomy cuts with subsequent fixation of zygomatic bone and additional bone contour plasty to correct the contour. Carrying out osteotomies for improperly fused bone fractures in the midface area followed by repositioning often leads to the formation of bone defects that require further surgical procedures. Otherwise, aesthetic deformations can be formed.

A new and interesting from a practical point of view is the use of Ni-Ti alloys as fixing devices. The advantage of these fixing structures is that when they are modeled and bent from the original dimensions, they still take the form specified in the course of production. Implants and tools from Ni-Ti-alloy are successfully applied in different fields of medicine.

Positive implant properties of Ni-Ti-alloy (NiTi, Nitinol):

- Very high corrosion resistance;
- High strength;
- High shape recovery ratio and high restoring force. Deformations can be completely cured in up to 8 %.
- Good compatibility with organisms;
- High damping capacity of material.

Disadvantages of the use of Ni-Ti-alloys fixing structures:

1. Wrong choice of the size will lead to the displacement of bone fragments after fixation;

2. Bending of fixing structure can lead to a change in the distance between the fractured bone fragments; this will result in incorrect position of bone fragments.

Disadvantages of the use of Ni-Ti-alloys implants:

1. The need for a large variety of sizes of implant, according to the anatomical area of their use;

2. Necessity of fixing implants to bone supports, often in the buttress area;

3. Form-memory can both improve the soft tissue contour with sufficient support from the side of the underlying structures, and deform the underlying structures due to the pressure of the proper soft tissues or post-traumatic / post-operative scars. The latter raises questions with the use of implants of Ni-Ti to close the defects of the anterior wall of the maxillary sinus, especially when using implants of Ni-Ti in the attachment without fixation along the crest (by buttress). When fixing implants from Ni-Ti alloys, pressure on the fixing elements due to shape memory is possible, what can worsen implant fixation over time.

Early surgical treatment within 24–48 hours after trauma has advantages, as increasing swelling complicates reposition and fixation of bones of the midface. Alternatively, reposition and fixation can take place a few days after the reduction of the swelling.

Untimely surgical treatment leads to incomplete recovery of function and appearance, this can negatively affect psychological state of patients.

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