Definition of the concept and history of the orbitozygomatic approach development

The orbitozygomatic approach (OZA), along with the pterional approach, is one of the most versatile anterolateral approaches to the skull base. The terms “unilateral transbasal” and “orbitozygomatic infratemporal” are synonyms of the term “orbitozygomatic”. Currently, orbitozygomatic approaches comprise a group of surgical approaches to the skull base that suggest involvement of elements of the orbital walls (superior and lateral) and zygomatic bone into the bone block formed during osteotomy. The OZA, which has integrated several limited basal approaches (pterional, supraorbital, zygomatic), is a combined anterolateral approach that perfectly matches the conceptual principle of skull base surgery — to minimize brain retraction. Like any other approach to the skull base, the OZA provides a wide view, short distance to the target region, direct approach, and opportunity to work at various angles, with injury to and retraction of critical neurovascular structures being minimal [1].

The history of surgical approaches to the skull base, which are associated with osteotomy of the orbital walls and zygomatic bone, began in the late XIX century. Resection of the outer orbital wall and zygomatic bone was pioneered by Czermak in 1894, then Gangolphe and Rollet (1901) and Kocher (1907) suggested their techniques.

In 1967, a Bulgarian neurosurgeon L. Karagezov [2] described a new transcranial approach to the orbit, which was also convenient for accessing intracranial mediobasal structures. In this case, an osteoplastic flap included a large part of the superior and outer walls of the orbit. However, the approach was technically complicated and did not gain wide recognition.

In 1982, J. Jane et al. [3] proposed a successful modification of the cranio-orbital approach based on studies by L. McArthur and C. Frazier [4, 5], which was called a supraorbital approach. This method was widely used, and its various modifications were developed, in which the flap included the temporal bone, zygomatic bone, and zygomatic arch (supraorbital-pterional, orbitozygomatic, midline supraorbital) [6—10]. In 1984, P. Pellerin et al. [11] described a two-stage orbito-frontozygomatic surgical approach to hyperostotic sphenoid wing meningiomas and reconstruction of the skull base with an autologous bone (cortex of the ilium). Using the technique of P. Pellerin, A. Hakuba et al. [12] developed in 1986 a new surgical approach — the orbitozygomatic-infratemporal approach that widely opened the orbit and base of the anterior and middle cranial fossae. We would say that this is the most versatile approach to extended tumors of the base of the anterior, middle, and posterior (superior parts) cranial fossae.

Two OZA modifications were used: a one-piece approach by K. Ikeda et al. [13] (single fronto-temporo-orbito-zygomatic bone flap) and a two-piece approach, in which convexity craniotomy was first performed, followed by the formation of an orbitozygomatic bone flap. Further practice has demonstrated that the second modification is more preferable (see below).

In 1993, I. Janecka and L. Sekhar [14] described two combined craniofacial approaches: anterior and anterolateral. The anterolateral craniofacial approach was performed through bicoronal and facial incisions, according to Weber-Fergusson. They cut a frontotemporal bone flap and then a facial flap, the size of the latter depended on the tumor spread.

In 1996, Y. Taguchi et al. [15] improved the double-flap cranio-orbital approach by eliminating the risk of postoperative enophthalmos through preserving the lateral orbital wall integrity.

In 1998, J. Zabramski et al. [16] presented a large study (83 cases) on the use of their own OZA modification, in which the bone block was separated with a minimal bone loss, which enabled full restoration of the facial skeleton contours at the end of surgery. Currently, two classic OZA modifications are used: the one-piece OZA used, and its various modifications were developed, in which the flap included the temporal bone, zygomatic bone, and zygomatic arch (supraorbital-pterional, orbitozygomatic, midline supraorbital) [6—10]. In 1984, P. Pellerin et al. [11] described a two-stage orbito-frontozygomatic surgical approach to hyperostotic sphenoid wing meningiomas and reconstruction of the skull base with an autologous bone (cortex of the ilium). Using the technique of P. Pellerin, A. Hakuba et al. [12] developed in 1986 a new surgical approach — the orbitozygomatic-infratemporal approach that widely opened the orbit and base of the anterior and middle cranial fossae. We would say that this is the most versatile approach to extended tumors of the base of the anterior, middle, and posterior (superior parts) cranial fossae.

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(a bone flap includes the zygomatic process of the frontal bone, frontal process of the zygomatic bone, 1/2 or 1/3 of the zygomatic bone body, temporal process of the zygomatic bone, and zygomatic process of the temporal bone) and the two-piece OZA (an orbitozygomatic bone flap is supplemented by pterional and frontotemporal craniotomy). The two-piece OZA provides a better view of the basal portions of the frontal lobe and reduces the risk of enophthalmos and cosmetic defects [17].

**Surgical technique**

Here, we provide a description of the OZA technique with allowance for the modern principles of cranial base surgery [2, 18—20].

The patient is in the supine position, with the head rotated contralaterally 45—60° and slightly tilted.

A skin incision starts at the zygomatic arch level, 1 cm anterior to the tragus, and extends superiorly along the coronal suture, departing at least 2 cm from the hairline (Fig. 1 and 2). This incision placement obviates injury to the main trunk of the superficial temporal artery. A skin-aponeurotic flap is separated from the periosteum and temporal fascia, not reaching 2.5 cm to the frontozygomatic suture in order to preserve the frontal branch of the facial nerve located in interfascial tissue. At the superior temporal line level, a myofascial “cuff” is formed by two parallel incisions. The first incision dissects the periosteum above the superior temporal line, and the second incision dissected the temporal fascia below the superior temporal line. Both incisions are joined anteriorly, not reaching 2.5 cm to the frontozygomatic suture. Further dissection is performed subperiosteally and subfascially (see below).

The periosteum is additionally dissected medially, from the posterior edge of the existing incision along the skin incision, forming a “triangular”, brow ridge-based flap. The squama of the frontal bone is elevated to the superior orbital rim using a raspatory. The temporal fascia is dissected from the “cuff” laterally to the zygomatic arch, also along the skin incision, thereby forming a “triangular” fascial flap (Fig. 2). Both “triangles” are pulled anteriorly and inferiorly. Then, subfascial dissection is performed by elevating the fascia from the muscle and simultaneously coagulating and transecting veins towards the superolateral margin of the zygomatic bone. In this way, subperiosteal separation of the superior orbital rim, zygomatic process of the frontal bone, frontal process of the zygomatic bone, body of the zygomatic bone, temporal process of the zygomatic bone, and zygomatic process of the temporal bone is carried out. The zygomaticofacial artery exiting from the lateral surface of the zygomatic bone body is coagulated and transected. It is recommended not to dissect the masseter muscle attached to the inferior margin of the zygomatic arch in order to minimize the risk of postoperative osteomyelitis of the orbitozygomatic bone flap.

The periosteal flap, temporal fascia, and temporal muscle (totally or its inner layer) in the form of advanced pedicle flaps can be used for reconstruction of a skull base defect at the end of surgery. If formation of a large defect is initially planned, it is advisable to use a bicoronal skin incision to form a large flap of the calvarial periosteum with a feeding base on the supraorbital ridge side where the flap receives blood supply from the supraorbital and supratrochlear arteries.

The next stage is dissection of the temporal muscle (Fig. 3). Like the temporal fascia, the muscle is dissected vertically and horizontally and elevated from the temporal fossa subperiosteally using a raspatory to preserve the intraperiosteal branches of the deep temporal arteries irrigating the muscle. This reduces the risk of postoperative atrophy of the temporal muscle, which manifests as a pronounced cosmetic defect. The temporal muscle is separated from the temporal bone squama, greater wing of the sphenoid bone, and posterior surface of the zygomatic bone as inferiorly as possible, after which the muscle is stitched and pulled laterally.

The periorbita is gently elevated from the superior and outer walls of the orbit to the depth of 2—3 cm. OZA osteotomy is performed with a burr or oscillating saw in three stages (Fig. 4):

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**Fig. 1.** Topography of anatomical landmarks of the calvarium and temporal and zygomatic regions with regard to the orbitozygomatic approach.

1 — coronal suture; 2 — superior temporal line; 3 — superficial temporal artery; 4 and 5 — frontal and parietal branches of the superficial temporal artery; 6 — frontal branch of the facial nerve; 7 — supraorbital neurovascular bundle; 8 — frontozygomatic suture; 9 — posterior margin of the frontal process of the zygomatic bone; 10 — zygomatic arch.
soft tissues are retracted with a spatula to avoid their injury.

The remaining fixation of the orbitozygomatic bone flap to the zygomatic and sphenoid bones is coped by careful lifting of the flap, starting with the zygomatic bone body side; after this, the flap is completely mobilized. The flap is pulled down on the masseter muscle, opening access to the infratemporal fossa.

The order of the two-piece OZA stages is obvious: craniotomy should come before cutting the orbitozygomatic bone flap. This provides greater preservation of the superior and outer walls of the orbit, which thereby are included in the orbitozygomatic flap. This provides better functional and cosmetic outcomes in the postoperative period.

Pterional craniotomy, if it is required, is carried out in accordance with the standard principles covered in manuals on neurosurgical techniques.

Further stages of the surgery should be performed under optical zooming, preferably under control of an operating microscope.

The dura mater is separated from the sphenoid crest and sphenoid wings to the anterior inclined process, superior orbital fissure, the round, oval, and sphenotic foramina, and petrous pyramid, if necessary. The periorbita is elevated from its walls to the superior and middle thirds of the superior orbital rim and extends down along the lateral orbital rim, using a flexible spatula to protect the periorbita, and placing a burr on the temporal fossa side. This osteotomy runs vertically down through the greater wing of the sphenoid bone and ends in the inferior orbital fissure region;

b) the second cut, which runs through the body of the zygomatic bone at the border of its middle and superior thirds or at the mid-level, starts on the orbit side, with a spatula being placed in advance to protect the periorbita. Simultaneously, soft tissues are pulled with a hook to maximally expose the lateral surface of the zygomatic bone body to its posteroinferior margin facing towards the infratemporal fossa. In this cut, the maxillary sinus may be opened, usually when osteotomy runs through the middle of the zygomatic bone body. This low cut is not required in a standard situation; it is only necessary for an additional increase in the angle of a surgical action and in special situations of a severe extracranial spread of a craniofacial neoplasm. In other cases, the zygomatic bone body is cut off at the border of its middle and superior thirds;

c) the third, final cut is carried out through the zygomatic process of the temporal bone vertically, after displacing the temporal muscle anteriorly; in this case, the first cut starts at the border of the outer and middle thirds of the superior orbital rim and extends down along the lateral orbital rim, using a flexible spatula to protect the periorbita, and placing a burr on the temporal fossa side. This osteotomy runs vertically down through the greater wing of the sphenoid bone and ends in the inferior orbital fissure region;

c) the third, final cut is carried out through the zygomatic process of the temporal bone vertically, after displacing the temporal muscle anteriorly; in this case, the first cut starts at the border of the outer and middle thirds of the superior orbital rim and extends down along the lateral orbital rim, using a flexible spatula to protect the periorbita, and placing a burr on the temporal fossa side. This osteotomy runs vertically down through the greater wing of the sphenoid bone and ends in the inferior orbital fissure region;
inferior orbital fissures; then, retractors are placed on the periorbita and dura mater to ensure safe osteotomy. The remaining medial part of the sphenoid crest is resected to expose the superior orbital fissure. The lateral and superior margins of the superior orbital fissure are removed by a burr. In our practice, we prefer minimal resection of the orbital roof to prevent postoperative pulsating enophthalmos.

The optic canal is opened extradurally using fine bone forceps to expose the optic nerve sheath. To expose the clinoind segment of the internal carotid artery, the anterior clinoid process, along with its root, is cut using a small spherical burr with diamond coating, under irrigation. These manipulations facilitate mobilization of the internal carotid artery and optic nerve after opening the dura mater and simplify surgical manipulations in the anterior and middle cranial fossae, parasellar area, and interpeduncular cistern. The anterior clinoid process is cut from inside to the thin bone plate that is easily removed using forceps.

Resection of the inferolateral parts of the greater wing of the sphenoid bone enables wide exposure of the inferior orbital fissure and round foramen located in the fissure projection, with the oval foramen being visualized behind the round foramen. Extradural dissection enables exposure of the middle meningeal artery, which enters the cranial cavity through the spinous foramen. Further dissection exposes the greater petrosal nerve posteriorly to the oval foramen; injury to the nerve can cause ipsilateral anhidrosis. The greater petrosal nerve is transected in rare cases when access to the petrosal segment of the internal carotid artery is required.

In our view, electrophysiological monitoring should be used to preserve the superior orbital fissure nerves of the cavernous sinus; this reduces the rate of complications associated with dysfunction of the oculomotor muscles [21].

The choice of the extradural or intradural approach is based on the features of the tumor location and spread.

Once the surgical manipulations are completed, tight suturing the dura mater is performed. Dura defects can be closed by a free flap of the calvarial periosteum. In the case of a large dura defect in the area of the superior orbital fissure and anterior parts of the cavernous sinus, which is often observed in meningiomas of the medial portions of the sphenoid wings, it is advisable to use combined reconstruction using a periosteal flap and advanced pedicled buccal flap (this reconstruction technique is described in detail and illustrated in our publications) with fixation of the plasty material by sutures and adhesive compositions [22, 23]. The orbitozygomatic (and pterional, in the case of a two-piece OZA) flap is placed back and fixed with titanium miniplates and screws or nonabsorbable sutures. If a substantial deficit of bone tissue of the orbital walls, especially the orbital roof, is observed during replacement of bone flaps, reconstruction of bone defects is recommended for prevention of pulsating enophthalmos. The temporal muscle is placed in its bed and sutured with single sutures to the myofascial “cuff” and to the posterior transected part of the muscle. The temporal fascia is sutured in the same way in a separate layer. The aponeurosis and skin are sutured in two layers.

The standard practice is placing a U-shaped (mattress) suture on the eyelids and a moderately compressing bandage on the eyeball to prevent aggravation of orbital tissue edema and chemosis. It is very important to moisten the conjunctiva because the lack of moistening in the presence of chemosis may cause cicatricial changes [20]. Therefore, starting the first postoperative day, the patient should be daily examined by an ophthalmologist for toilet of the conjunctival cavity. Sutures are removed from the eyelids and a compressing bandage is canceled on the 5th postoperative day in the absence of eyelid edema and chemosis. An ice bag or cold compresses can be used to prevent periorbital edema.
Advantages of the orbitozygomatic approach in surgery of skull base tumors and circle of Willis aneurysms

The OZA has been extensively used in neurosurgery and has been reasonably considered the “work horse” of skull base surgery [24, 25]. The OZA, which is in fact an extension of the pterional approach [24], surpasses it due to removal of a flap comprising the superior and lateral orbital walls and zygomatic arch as well as retraction of the temporal muscle and contents of the orbit to increase the angle of view. These differences are of key importance for expanding the surgical corridor and reducing retraction of the frontal and temporal lobes [20, 26, 27]. Special measurements demonstrated that the differences in angles of the operating action in the pterional and orbitozygomatic approaches are significant. According to A. Nanda et al. [28], the anteroposterior angle was 56±5° with the OZA versus 48±6° with the pterional approach (p<0.01), while the rostrocaudal angle was 61±9° versus 51±9° (p<0.05), respectively. An increased amount of bone resection when using the OZA instead of the pterional approach transforms a narrow space into a wide corridor, enabling the surgeon to work closer to the target without additional retraction of the brain. According to the evaluation by L. Gonzalez et al. [29], the difference in the angle of vertical visibility is 10.2±0.7°; when the orbitozygomatic flap includes a maxilla fragment (maxillary expansion), extra 4.8±0.6° is added. These data are consistent with the results of our measurements: compared to the pterional approach, the angle of surgical view with the OZA increases by 27° (84%) in the frontal plane and 19° (60%) in the horizontal plane.

In a study by E. Figueiredo et al. [30], the vertical and horizontal angles of the approach were larger for the OZA than for the pterional approach. Since the vertical approach angle is limited by retraction of the frontal lobe, it is statistically significantly larger in the OZA. The value of the angle of horizontal visibility in the OZA was also statistically significantly larger than that in the pterional approach. In a study by V. Filipee et al. [31], in microscopic exposure, the greatest working area (204.5±33.9 mm2) was provided by the OZA as compared to the supraorbital (114.8±26 mm2) and pterional (170±20.4 mm2) (p<0.05) approaches.

A number of authors [20] argue that it is sufficient to complement pterional craniotomy by mobilization of the zygomatic arch. But in this modification, the temporal muscle restricts the vertical angle of visibility; therefore, the ideal solution is osteotomy of the entire zygomatic bone, like in the OZA, which provides withdrawal of the temporal muscle beyond the surgical corridor.

The OZA has been actively used for skull base tumors and vascular pathology [27]. The approach provides a wide view of the anterior and middle cranial fossae, area of the basilar artery apex and superior parts of the clivus, infratemporal and pterygopalatine fossae, apex of the petrous pyramid, and tentorial notch region [1, 20, 26—28, 32]. The indications for using the OZA include aneurysms of the anterior cerebral and anterior communicating arteries, sphenoid wing meningiomas, basilar bifurcation aneurysms, craniopharyngiomas, pituitary adenomas, chordomas, parasellar meningiomas, and Meckel’s cavity tumors (meningiomas, neuromas) [20].

The OZA is convenient for resecting trigeminal nerve neuromas located in the middle and posterior cranial fossae, which cause erosion of the apex of the petrous pyramid. However, a large size of the tumor site in the posterior fossa prevents complete tumor resection using the approach [26].

The OZA increases visibility of the medial portions of the temporal lobe and has advantages over the traditional subtemporal approaches because it provides a convenient and minimally traumatic approach to the internal carotid artery branches (anterior choroid, posterior cerebral, and posterior communicating arteries), minimizes retraction of the temporal lobe and the risk of injury to the vein of Labbe, and avoids transcortical manipulations or lobectomy having the risk for language and memory functions [33].

In neurovascular surgery, the OZA has been recognized as one of the approaches to the anterior parts of the circle of Willis and basilar artery apex. The credit for popularizing the OZA in surgery of cerebral aneurysms is due to M. Yasargil [29].

The advantage of OZA is improved visibility of the A1—A2 segments of the anterior cerebral artery and anterior communicating artery along the vertical and horizontal axes without the need for resection of the straight gyrus [30, 31]. According to M. Kinoshita et al. [34], the OZA is the only approach that enables visualization of these structures without significant retraction of the brain.

The basilar artery apex area is one of the most complex and hard-to-reach areas on the inferior cerebral surface. In this respect, it is necessary to note advantages of endoscopic assistance that provides excellent visibility of the basilar artery bifurcation without the need for dissection of the lateral wall of the cavernous sinus, which simplifies access to this anatomical area [28].

Postoperative results and outcomes were the object of several studies that compared the OZA with pterional and other approaches to the anterior and posterior parts of the skull base. The literature data are quite contradictory. For example, according to A. Nanda et al. [28], the OZA is a more traumatic approach and increases the surgery duration. G. Lemole et al. [27] argue that this extended approach increases postoperative morbidity compared to that of the pterional approach. At the same time, A. Youssef et al. [25] demonstrate that the OZA neither significantly increases postoperative morbidity nor leads to poor cosmetic outcomes. According to W. van Furth et al. [20], the cosmetic outcome in the case of
a properly performed OZA is the same as in the pteleral approach, and ptosis may persist after surgery for several weeks, but usually completely regresses. Only 2 of 250 patients had partial ptosis for longer than 6 months.

A. Youssef et al. [25] analyzed a series of 75 patients operated on for various craniofacial lesions using the OZA and reported the following data on complications: ocular movement restriction (2.4%), cranial nerve injury (8.5%), liquorrhoea (1.2%), pseudomeningocele (2.4%), and intracerebral hemorrhage (1.2%). No one of the cranial nerve deficit cases was associated with the approach, except a single case of optic nerve injury during clinoidecotomy. It should be noted that postoperative complications were more frequently associated with tumors than with vascular pathology. 78.5% of patients were satisfied with the cosmetic outcome of surgery.

Conclusion

The OZA is one of the basic approaches in skull base surgery because of its obvious advantages and executability. A statistically significant increase in the angle of attack, the possibility of extending the surgical field, and no need for retraction of the frontal and temporal lobes are the indisputable advantages of this approach that make it indispensable in a number of situations. It should be noted that modern neurosurgery gives preference to the two-piece OZA because this surgical technique minimizes resection of the bone walls of the orbit because of their inclusion in the orbitozygomatic flap, which is not technically possible in the case of a single fronto-temporo-orbito-zygomatic flap.

REFERENCES

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