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Topographic anatomy of two-piece orbitozygomatic, modified orbitozygomatic and transzygomatic approaches: A comparative analysis of neurosurgical options

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Abstract

Aim – to measure and compare the vertical and horizontal angles of attack on different intracranial surgical targets provided by the transzygomatic, modified orbitozygomatic and classic two-piece orbitozygomatic approaches, to determine the most optimal approaches to different surgical targets.

Material and methods. The study was conducted on 8 sides of en bloc specimens of human head and neck. The marking was performed with BrainLAB Kolibri navigational station (Germany) to highlight the surgical landmarks and measure the angles. The dissection was started macroscopically with standard instruments and photographic fixation of every stage of the approach. The craniotomy was performed with Stryker high speed drill (USA). After that, the microscopic stage was carried out with the ZEISS OPMI Vario/S88 surgical microscope (Germany). On each side, the following steps were completed: soft tissues dissection, cutting the zygomatic arch, fronto-temporal craniotomy, orbitozygomatic osteotomy, opening of the dura mater and dissection of structures of the cranial base, measurement of angles of attack with their apex located on skull base structures

Results. The angles of attack on different intracranial surgical targets were measured and compared for two-piece orbitozygomatic, modified orbitozygomatic and transzygomatic approaches.

Conclusion. The two-piece orbitozygomatic craniotomy is the most universal and optimal to approach the basilar artery bifurcation and lesions located in both anterior and middle cranial fossae. However, to minimize the surgical trauma and the risks of complications when exposing exclusively anterior cranial fossa, the modified orbitozygomatic approach is more adequate. When the lesion is small and located exclusively in middle cranial fossa, performing the transzygomatic approach is recommended.

Keywords: orbitozygomatic approach, neurosurgery, supraorbital approach, orbito-pterional approach, transzygomatic approach.
Conflict of interest: nothing to disclose.

Citation
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Топографическая анатомия двухлоскутного орбитозигоматического, модифицированного орбитозигоматического и трансзигоматического доступов: сравнительный анализ нейрохирургических возможностей

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Аннотация

Цель – измерить и сравнить вертикальные и горизонтальные углы, обеспечиваемые: трансзигоматическим, модифицированным орбитозигоматическим и классическим двухлоскутным орбитозигоматическим доступами, – на различные интракраниальные хирургические цели, определить наиболее оптимальный доступ для этих хирургических целей.

Материал и методы. Исследование проведено на 8 сторонах блок-препаратов «голова – шея». Выполнялась разметка с помощью навигационной станции BrainLAB Kolibri (Германия) для получения ориентиров и расчета углов атаки хирурга. Диссекцию начинали выполнять макроскопически с использованием стандартных инструментов и фотофиксацией каждого этапа доступа. При выполнении трепанации использовалась высокооборотистая дрель Stryker (США). Затем переходили на микроскопический этап с применением хирургического микроскопа ZEISS OPMI Vario/S88 (Германия). На каждой стороне выполнялись следующие этапы: диссекция мягких тканей; перепиливание скуловой дуги; лобно-височная трепанация, выпиливание орбитозигоматического лоскута; вскрытие твердой оболочки и диссекция структур основания черепа; измерение углов атаки с вершиной в области структур на основании черепа.

Результаты. Измерены и сравнены между собой углы атаки на различные интракраниальные хирургические цели при двухлоскутном орбитозигоматическом, модифицированном орбитозигоматическом и трансзигоматическом доступах.

Выводы. Двухлоскутный орбитозигоматический доступ является наиболее универсальным и оптимальным для подхода к бифуркации базилярной артерии, а также к распространенным сразу в передней и средней черепных ямках патологическим очагам. Однако для минимизации хирургической травмы и рисков осложнений при изолированном подходе к передней черепной ямке более предпочтительно выполнение модифицированного орбитозигоматического доступа, а при локализации небольшого изолированного патологического очага в средней черепной ямке рекомендуется производить трансзигоматический доступ.

Ключевые слова: орбитозигоматический доступ, нейрохирургия, трансзигоматический доступ, супраорбитальный доступ, орбитоптерионaльный доступ.

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ОЗД – орбитозигоматический доступ; ТЗД – трансзигоматический доступ; мОЗД – модифицированный орбитозигоматический доступ; СО – стандартное отклонение; ВСА – внутренняя сонная артерия; ЧМН – черепно-мозговой нерв.

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BACKGROUND

The orbitozygomatic approach (OZA) was first proposed in 1984 by Pellerin et al. His technique consisted of performing successive stages of osteoplastic trepanation of a portion of the frontal bone, creation of an orbitozygomatic flap (consisting of the upper edge of the orbit, zygomatic process of the frontal bone, frontal process of the zygomatic bone, part of the body of the zygomatic bone, and zygomatic arch), and resection of the squama of the temporal bone and external parts of the sphenoid bone wings [1]. Subsequently, this approach was repeatedly modified. In 1986, Hakuba et al. [2] described the use of single-flap orbitozygomatic craniotomy. In 1998, Zabramski et al. [3] presented a version of the two-flap OZA that is most commonly used today. The OZA has been widely applied in skull base surgery because it significantly increases the angles of attack on deep intracranial structures and reduces brain traction. This approach simultaneously opens approaches to the anterior and middle cranial fossae, upper parts of the clivus, apex of the petrous pyramid, and area of the incisure of the tentorium of the cerebellum [4–6] and to the orbit, infratemporal, and pterygopalatine fossae, which allows its use to remove various benign and malignant tumors with extra and intracranial spread [7, 8], and aneurysms of complex localization [9, 10].

In 1987, Al-Mefty proposed a single-flap supraorbital–pterional approach, which offers a wide access to the base of the anterior and middle cranial fossae and excludes the zygomatic arch in the flap [11]. In modern neurosurgery, this approach is called the modified orbitozygomatic approach (mOZA) or supraorbital OZA.

Isolated zygomatic osteotomy was first performed in 1956 by Samy and Girgis to gain access to the nasopharynx, petrous apex, and infratemporal fossa [12]. Currently, the transzygomatic approach (TZA) is an extended pterional approach with the removal of the zygomatic arch and is performed to approach the cavernous sinus, parasellar and suprasellar regions, interpeduncular cistern, incisure of the tentorium of the cerebellum, basilar artery bifurcation, sphenoid bone, trigeminal nerve, petrous pyramid, and other structures [13].

In the global and Russian literature, approximately 60 studies have examined the use of the OZA and its modifications in the surgical treatment of various pathologies. Although numerous anatomical studies have been conducted, no work currently provides a comparative description of the step-by-step implementation of various OZA options; accordingly, indications for choosing an approach option for various localizations of the pathological process have not been developed.

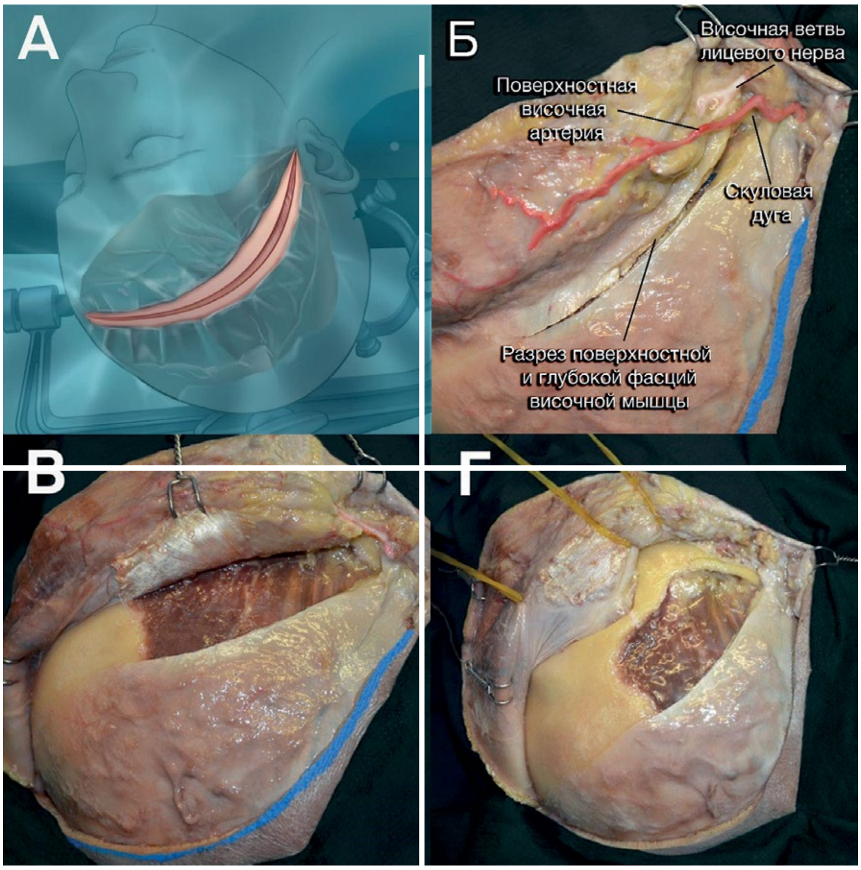


Figure 1. *Soft tissues dissection. 1A – skin incision. 1Б – subfascial dissection of the temporalis fascia with preservation of fronto-temporal branch of the facial nerve. 1B – reflecting the aponeurotic flap with superficial and deep temporalis fascia. 1Г – corpus, frontal and temporal processes of zygomatic bone, zygomatic process of temporal bone and zygomatic process of frontal bone are exposed.*

Рисунок 1. *Диссекция мягких тканей. 1А – кожный разрез. 1Б – субфасциальная диссекция височной фасции с сохранением лобно-височной ветви лицевого нерва. 1В – отсепаровка кожно-апоневротического лоскута вместе с глубокой и поверхностной фасцией височной мышцы. 1Г – обнажены тело скуловой кости с лобным и височным отростками, часть лобной кости со скуловым отростком и скуловой отросток височной кости.*

AIM

This study aimed to measure and compare the vertical and horizontal angles provided by the TZA, mOZA, and classic two-flap OZA for various intracranial surgical targets represented by anatomical structures often involved in pathological processes and, based on the data obtained, to determine the most optimal approach for these surgical targets.

MATERIAL AND METHODS

The study was conducted at the microsurgical laboratory of the Federal Center for Neurosurgery (Tyumen) on eight sides of the head–neck block specimens of cadaveric material from six deceased persons aged 45–86 years, whose death was not associated with a disease of the central nervous system. Block specimens were fixed in a 10% formalin solution. The internal carotid artery (ICA) and vertebral arteries of all block specimens were perfused with red-stained silicone, and the jugular veins were perfused with blue-stained silicone.

The study was performed in accordance with the requirements of

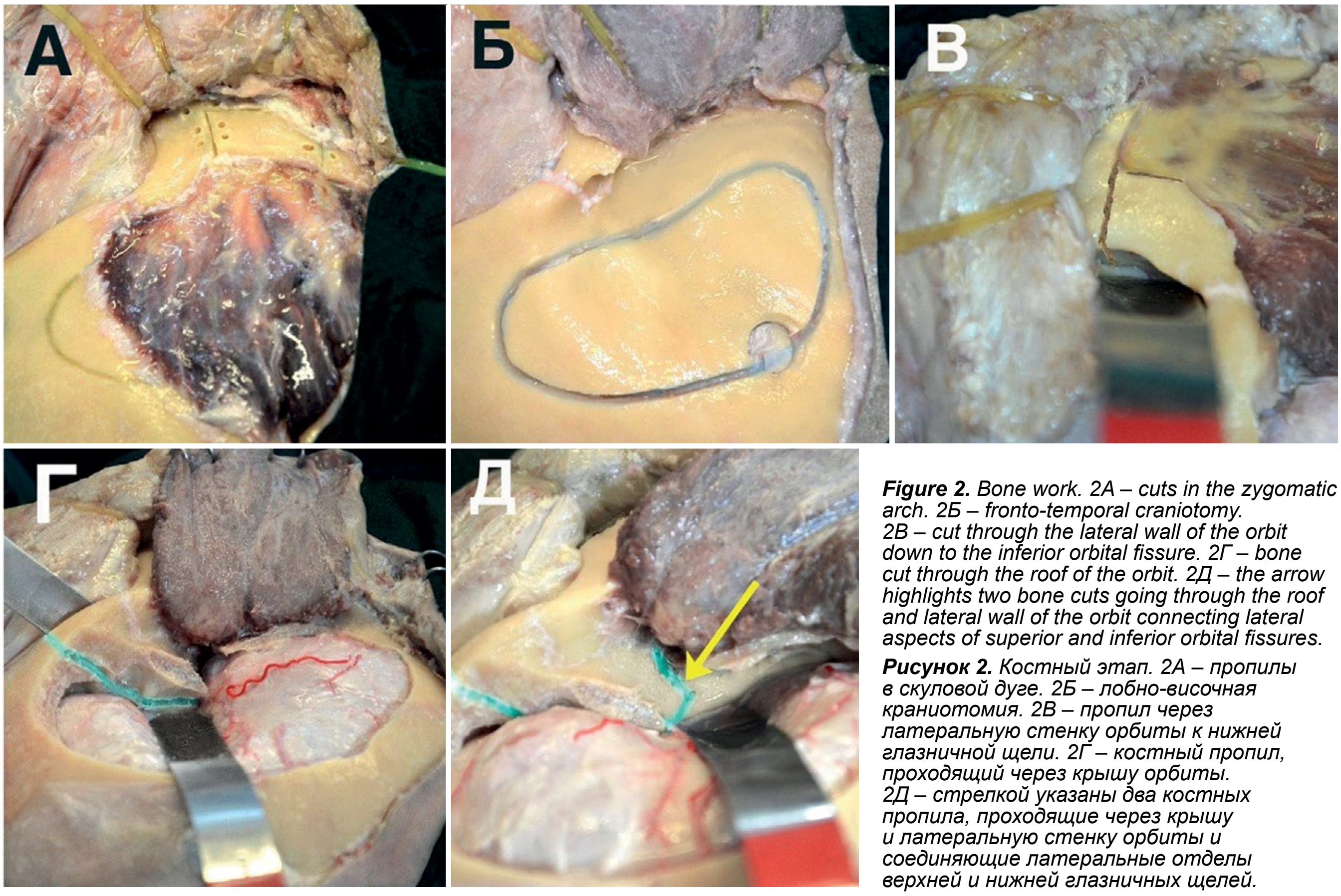


Figure 2. Bone work. 2A – cuts in the zygomatic arch. 2Б – fronto-temporal craniotomy. 2B – cut through the lateral wall of the orbit down to the inferior orbital fissure. 2Г – bone cut through the roof of the orbit. 2Д – the arrow highlights two bone cuts going through the roof and lateral wall of the orbit connecting lateral aspects of superior and inferior orbital fissures.

Рисунок 2. Костный этап. 2А – пропилы в скуловой дуге. 2Б – лобно-височная краниотомия. 2В – пропил через латеральную стенку орбиты к нижней глазничной щели. 2Г – костный пропил, проходящий через крышу орбиты. 2Д – стрелкой указаны два костных пропила, проходящие через крышу и латеральную стенку орбиты и соединяющие латеральные отделы верхней и нижней глазничных щелей.

the Declaration of Helsinki of the World Medical Association, which describes the ethical principles of medical research involving humans as subjects, including the study of identifiable materials and data obtained from humans, as well as in accordance with the ethical principles approved by the N.N. Burdenko National Medical Research Center for Neurosurgery (Moscow) and the Federal Center of Neurosurgery (Tyumen).

The main inclusion criterion in this study was the preservation of the bone and intracranial structures of the anatomical head–neck block specimen on the side where the analysis was performed. The exclusion criterion was damage to the bone and intracranial structures in this region.

Each head–neck block specimen was fixed in a rigid head holder in a position simulating a real surgical intervention. Subsequently, marking was performed using the BrainLAB Kolibri navigation station (Germany) to obtain landmarks and calculate the surgeon's angles of attack. Dissection was performed macroscopically using standard instruments and photographic recording of each stage of access. A high-speed drill Stryker (USA) was used for trepanation. Then, we proceeded to the microscopic stage using a ZEISS OPMI Vario/S88 surgical microscope (Germany). The steps of soft tissue dissection, sawing of the zygomatic arch, frontotemporal trepanation, cutting out an orbitozygomatic flap, opening of the dura mater and dissection of the skull base structures, and measurement of angles of attack with the apex in skull base structures were performed on each side.

Soft tissue dissection

After fixing the block specimen in a rigid head holder so that the zygomatic tubercle was the highest point of dissection, a skin incision was made, starting 1 cm anterior to the tragus at the level of the lower edge of the zygomatic arch, continuing upward and anteriorly, bending along the arc, and ending at the point of intersection of the hair growth zone with the contralateral midpupillary line (**Fig. 1A**). The aponeurotic skin flap was separated anteriorly, and a subfascial dissection of the temporal fascia and a subperiosteal dissection of the periosteum in the frontal region were performed (**Fig. 1B**). The deep temporal fascia was cut off at the point of its attachment to the zygomatic arch and separated along with the periosteum covering the zygomatic bone body with the frontal, temporal, and zygomatic processes of the frontal and temporal bones (**Figs. 1C and D**). The temporalis muscle was dissected, leaving a fascial cuff of 7–10 mm wide at the site of attachment to the superior temporal line and separated from the bone using the retrograde dissection technique described by Oikawa [14]. This technique consists of dissecting the temporalis muscle along the skin incision and separating it with a raspatory from the bone along the

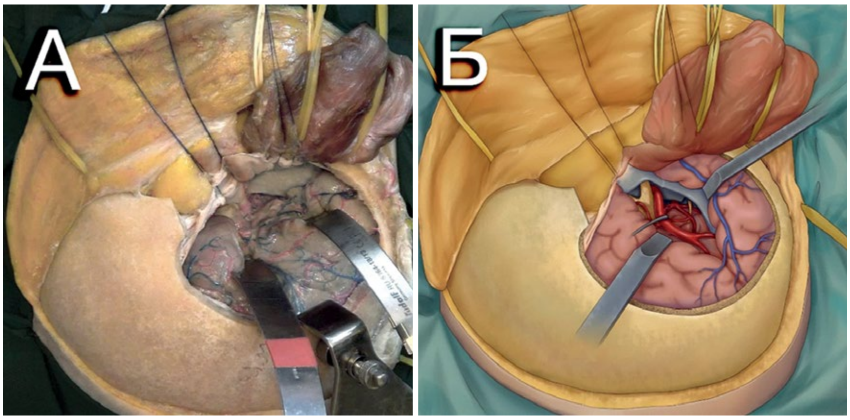


Figure 3. Surgical view after completed two-piece orbitozygomatic approach and skull base dissection of surgical targets to measure the angles of attack. 3A – anatomical specimen. 3Б – illustration.

Рисунок 3. Вид раны после выполнения двухлоскутного ОЗД и диссекции структур на основании черепа (хирургических целей) для измерения углов атаки. 3А – анатомический препарат. 3Б – рисунок.

muscle fibers from the bottom up, starting below the lower temporal line. Then, starting from the lateral edge of the orbital arch, the periorbita was separated from the superior and lateral walls of the orbit.

Sawing of the zygomatic arch, frontotemporal pterional craniotomy, and removal of the orbito-zygomatic flap

In the next step, the temporalis muscle to the skull base was retracted, and the zygomatic arch was sawed, capturing part of the zygomatic bone (**Fig. 2A**).

After sawing the zygomatic arch, the temporalis muscle was retracted basally, and the contour of the frontotemporal pterional craniotomy was outlined, reaching the basal parts of the squama of the temporal bone and the greater wing of the sphenoid bone. A frontotemporal craniotomy was performed within these boundaries using a craniotome and bur (**Fig. 2B**).

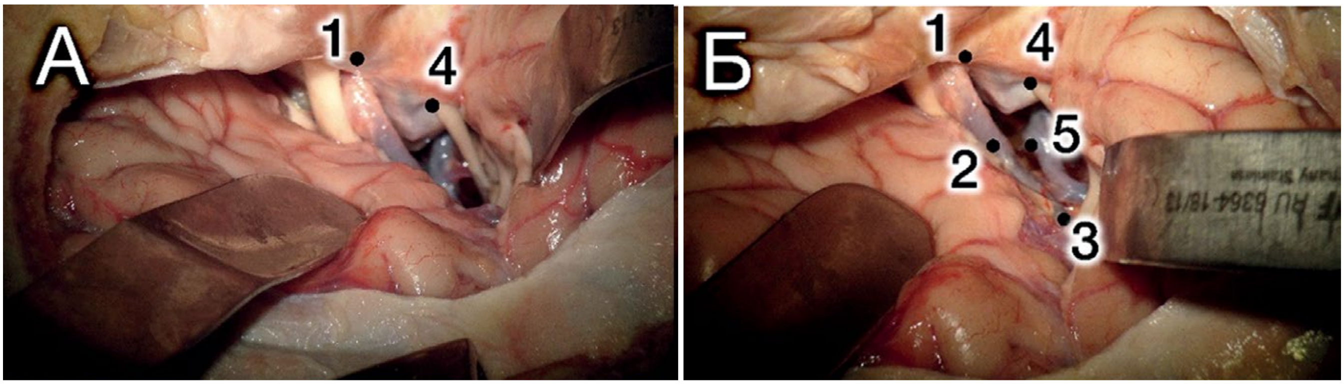
Furthermore, the zygomaticoorbital complex was removed. First, a cut was made through the body of the zygomatic bone toward the inferior orbital fissure. This cut started from a point located above the zygomatic tubercle and continued to the lateral edge of the orbit. The lateral wall of the orbit was then sawed to the lateral parts of the inferior orbital fissure (**Fig. 2C**).

The next bone cut was made through the superior orbital margin and roof of the orbit. The cut started from the middle sections of the upper edge of the orbit and continued through the orbit roof to the superolateral part of the superior orbital fissure (**Fig. 2D**).

Then, two cuts were made at the skull base to connect the superior and inferior orbital fissures (**Fig. 2E**).

Opening of the dura mater and dissection of the skull base structures

The dura mater was then opened using an arcuate incision with the base pointing toward the anterior and middle cranial fossae. The dura mater was obtained from the holders. Subsequently, under a microscope, a basal dissection was performed to the structures of the 1) anterior clinoid process on the ipsilateral



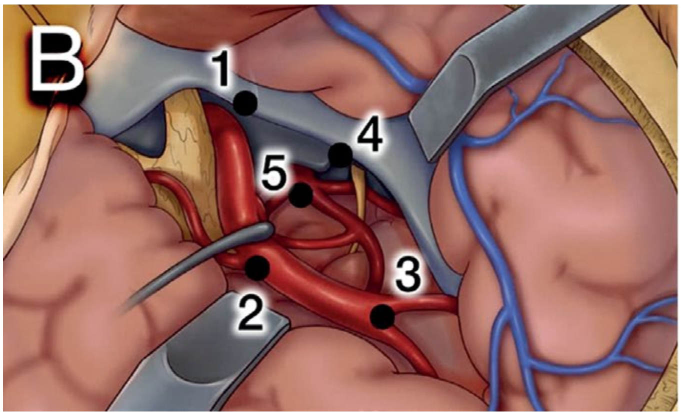


Figure 4. Skull base structures (surgical targets) which served as apexes for measuring of angles of the attack. A, Б – anatomic specimen, B – illustration. 1 – ipsilateral anterior clinoid process, 2 – bifurcation of the ipsilateral supraclinoid internal carotid artery, 3 – bifurcation of the ipsilateral middle cerebral artery, 4 – ipsilateral oculomotor (CN III) nerve triangle, 5 – superior bifurcation of the basilar artery.

Рисунок 4. Структуры на основании черепа (хирургические цели) – вершины для измерения углов атаки. А – анатомический препарат, Б – анатомический препарат, В – рисунок. 1 – передний наклоненный отросток на ипсилатеральной стороне, 2 – бифуркация супраклиноидного отдела внутренней сонной артерии на ипсилатеральной стороне, 3 – бифуркация средней мозговой артерии на ипсилатеральной стороне, 4 – треугольник глазодвигательного (ЧМН III) нерва на ипсилатеральной стороне, 5 – верхняя развилка основной артерии.

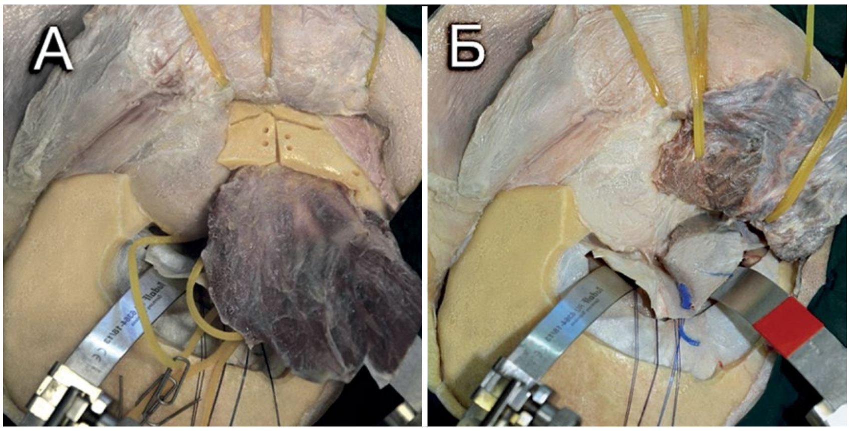


Figure 5. Zygomatic arch is returned to evaluate the angles of attack in modified (supraorbital) one-piece orbitozygomatic approach. A – temporalis muscle is returned and the zygomatic arch is put back; Б – temporalis muscle is reflected towards skull base, the conditions to measure the angles of attack in supraorbital approach are created.

Рисунок 5. Установлена скуловая дуга с целью измерения углов атаки для модифицированного (супраорбитального) однолоскутного ОЗД. А – отведена височная мышца, установлена скуловая дуга; Б – височная мышца откинута к основанию черепа, созданы условия для измерения углов атаки для супраорбитального доступа.

side, 2) bifurcation of the supraclinoid division of the ICA (the branching point into the anterior and middle cerebral arteries) on the ipsilateral side, 3) bifurcation of the middle cerebral artery on the ipsilateral side, 4) trigone (entry point into the cavernous sinus) of the oculomotor (III) nerve on the ipsilateral side, and 5) superior bifurcation of the basilar artery. Brain tissue was retracted with spatulas using rigid retractors.

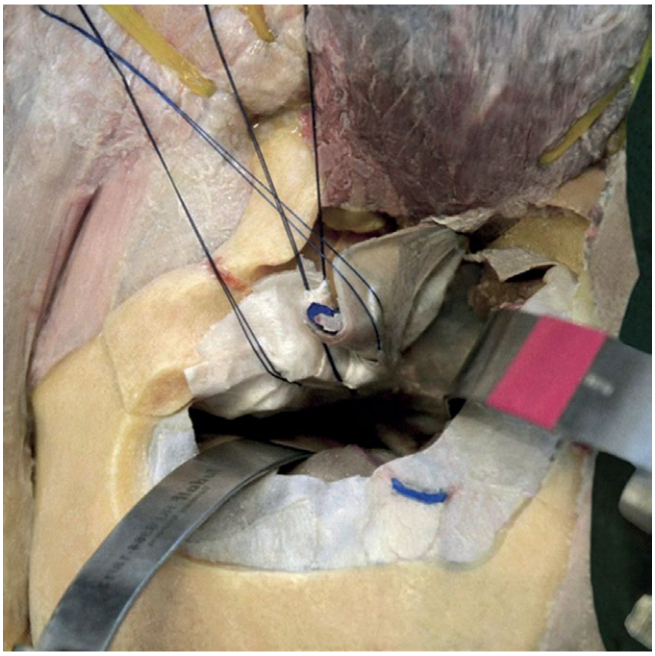


Figure 6. Supraorbital bone flap is returned and the zygomatic arch is removed to evaluate the angles of attack in transzygomatic approach.

Рисунок 6. Установлен супраорбитальный костный лоскут, удалена скуловая дуга для измерения углов атаки для трансзигоматического доступа.

During all measurements, we avoided disturbing the position of the retractors (**Fig. 3**).

Measuring angles of attack with the apex in skull base structures

For the completed two-flap OZA using the BrainLAB Kolibri stereotactic navigation system, the vertical and horizontal angles of attack were measured with the apex in the above-described targets. The angles were determined between two segments extending from each target until they touched the highest and lowest points, as well as the most anterior and most posterior points, respectively (**Fig. 4**).

After this measurement, the dura mater was retracted from the holders to the brain, and the zygomatic arch was installed; the orbitozygomatic flap was not returned to its place. The dura mater was placed on the holders. Thus, the angles of attack were measured when performing a modified (supraorbital) single-flap OZA (**Fig. 5**).

The dura mater was then retracted on the holders to the brain, the zygomatic arch was removed, and the orbitozygomatic flap was installed in its place with its fixation with bone sutures. The dura mater was then again retracted on the holders to the skull base. Thus, the angles of attack for the TZA was measured (**Fig. 6**).

RESULTS

Comparison of the vertical angles of attack

The average vertical viewing angle with the apex in the apex of the ipsilateral anterior clinoid process with a two-flap OZA was 50.00° (standard deviation 18.26°, median 45.5° [35.5°; 62.5°], minimum 30°, maximum 83°), that with the TZA was 39.12° (standard deviation 14.01°, median 35° [28.75°; 47.75°], minimum 25°, maximum 64°), and that with the mOZA was 49.5° (standard deviation 17.86°, median 46° [35°; 59.25°], minimum 30°, maximum 83°).

The average vertical viewing angle with the apex in the ipsilateral bifurcation of the ICA with a two-flap OZA was 44.88° (standard deviation 13.84°, median 46.5° [31.5°; 53°], minimum 30°, maximum 68°), that with the TZA was 33.62° (standard deviation 13.08°, median 33.5° [26°; 45.25°], minimum 13°, maximum 50°), and that with the mOZA was 43.38° (standard deviation 13.10°, median 44° [31.5°; 51°], minimum 28°, maximum 65°).

The average vertical viewing angle with the apex in the bifurcation of the ipsilateral medial cerebral artery (MCA) when performing a two-flap OZA was 72.25° (standard deviation 10.86°, median 75° [68.75°; 78.5°], minimum 50°, maximum 85°), that with the TZA was 71.25° (standard deviation 11.76°, median 74.5° [68.25°; 77°], minimum 47°, maximum 85°), and that with the

Surgical target	Average angle of attack in degrees (±SD)			p-Value
	OZA	TZA	mOZA	
Anterior clinoid process	50±18	39±14	49±13	.0014
ICA bifurcation	44±13	33±13	43±13	.0009
MCA bifurcation	72±10	71±11	60±13	.0009
Trigone of nerve III	58±14	57±12	47±11	.0016
Superior bifurcation site of the basilar artery	33±9	33±9	26±7	.0014

Table 1. *Vertical angles of attack in two-piece orbitozygomatic approach, transzygomatic approach and modified orbitozygomatic approach*

Таблица 1. *Вертикальные углы атаки при выполнении двухлоскутного ОЗД, трансзигоматического доступа и модифицированного ОЗД*

Surgical target	Average angle of attack in degrees (±SD)			p-Value
	OZA	TZA	mOZA	
Anterior clinoid process	80±20	59±15	80±20	.0012
ICA bifurcation	66±14	64±14	65±12	.1835
MCA bifurcation	72±22	58±21	71±22	.0012
Trigone of nerve III	61±16	44±15	61±16	.0016
Superior bifurcation site of the basilar artery	31±6	21±6	30±6	.0005

Table 2. *Horizontal angles of attack in two-piece orbitozygomatic approach, transzygomatic approach and modified orbitozygomatic approach*

Таблица 2. *Горизонтальные углы атаки при выполнении двухлоскутного ОЗД, ТЗД и мОЗД*

mOZA was 60.00° (standard deviation 13.10°, median 44° [31.5°; 51°], minimum 28°, maximum 65°).

The average vertical viewing angle with the apex in the ipsilateral trigone of the oculomotor nerve when performing a two-flap OZA was 58.00° (standard deviation 14.21°, median 61° [54°; 68.5°], minimum 30°, maximum 72°), that with the TZA was 57.62° (standard deviation 12.72°, median 61° [55°; 65.75°], minimum 32°, maximum 70°), and that with the mOZA was 47.88° (standard deviation 11.68°, median 52° [46.75°; 53.5°], minimum 28°, maximum 60°).

The average vertical viewing angle with the apex in the apex of the basilar artery when performing a two-flap OZA was 33.75° (standard deviation 9.39°, median 33.5° [26.75°; 42°], minimum 21°, maximum 45°), that with the TZA was 33.38° (standard deviation 9.15°, median 32° [26.75°; 41°], minimum 22°, maximum 46°), and that with the mOZA was 26.50° (standard deviation 7.95°, median 27° [21.5°; 32.25°], minimum 15°, maximum 38°) (**Table 1**).

Comparison of the horizontal angles of attack

The average horizontal viewing angle with the apex in the apex of the ipsilateral anterior clinoid process with a two-flap OZA was 80.88° (standard deviation 20.84°, median 84.5° [67.75°; 91°], minimum 48°, maximum 115°), that with the TZA was 59.88° (standard deviation 15.14°, median 60° [48.75°; 72°], minimum 38°, maximum 80°), and that with the mOZA was 80.62° (standard deviation 20.69°, median 85° [66.75°; 91.75°], minimum 48°, maximum 113°).

The average horizontal viewing angle with the apex in the ipsilateral bifurcation of the ICA with the two-flap OZA was 66.38° (standard deviation 14.01°, median 70° [61.5°; 72.5°], minimum 42°, maximum 87°), that with the TZA was 64.38° (standard deviation 14.61°, median 67° [53.75°; 72.75°], minimum 42°, maximum 87°), and that with the mOZA was 65.50° (standard deviation 12.64°, median 69° [62°; 70.75°], minimum 42°, maximum 83°).

The average horizontal viewing angle with the apex in the bifurcation of the ipsilateral MCA when performing a two-flap OZA was 72.38° (standard deviation 22.15°, median 72° [51.5°; 89°], minimum 46°, maximum 105°), that with the TZA was 58.12° (standard deviation 21.94°, median 59.5° [38.75°; 75°], minimum 30°, maximum 91°), and that with the mOZA was 71.50° (standard deviation 22.28°, median 71.50° [51.5°; 87.75°], minimum 43°, maximum 105°).

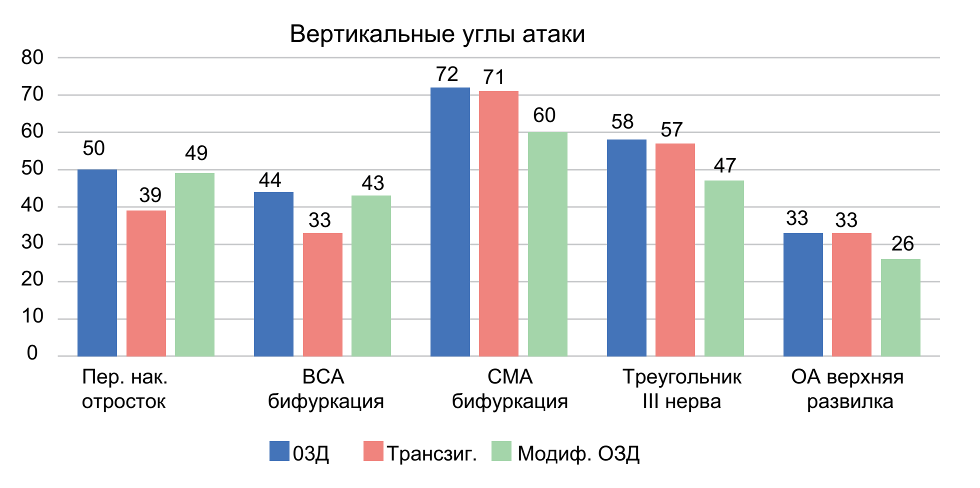


Figure 7. *A joint diagram of comparison of the vertical angles of attack on the surgical targets on the cranial base in two-piece orbitozygomatic approach, transzygomatic approach and modified orbitozygomatic approach.*

Рисунок 7. *Сводная диаграмма сравнения вертикальных углов атаки к хирургическим целям на основании черепа при выполнении двухлоскутного ОЗД, ТЗД и мОЗД.*

The average horizontal viewing angle with the apex in the ipsilateral trigone of the oculomotor nerve when performing a two-flap OZA was 61.88° (standard deviation 16.47°, median 65.5° [48.25°; 73°], minimum 39°, maximum 84°), that with the TZA was 44.88° (standard deviation 15.61°, median 52.5° [31.25°; 54.25°], minimum 20°, maximum 64°), and that with the mOZA was 61.12° (standard deviation 16.30°, median 64° [47.75°; 71°], minimum 40°, maximum 84°).

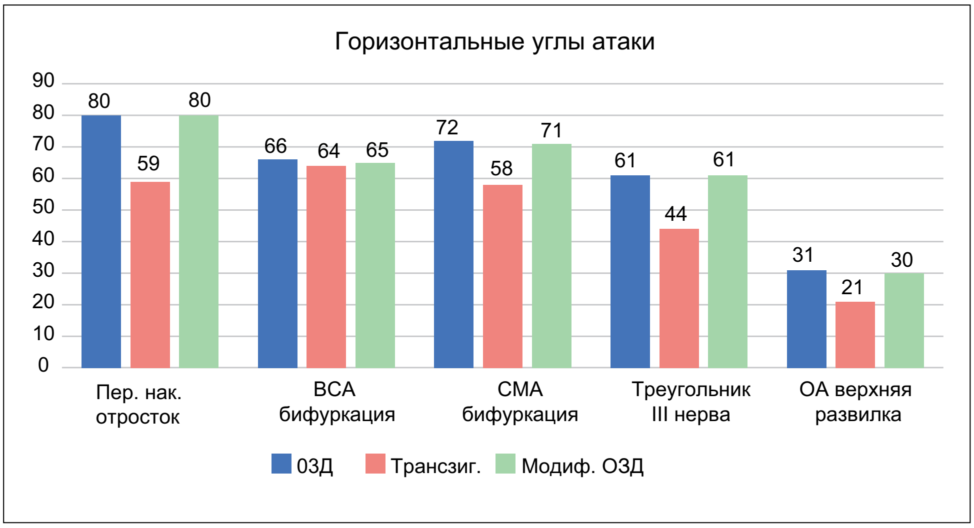


Figure 8. *A joint diagram of comparison of the horizontal angles of attack on the surgical targets on the cranial base in two-piece orbitozygomatic approach, transzygomatic approach and modified orbitozygomatic approach.*

Рисунок 8. *Сводная диаграмма сравнения горизонтальных углов атаки к целям на основании черепа при выполнении двухлоскутного ОЗД, ТЗД и мОЗД.*

The average horizontal viewing angle with the apex in the apex of the basilar artery when performing a two-flap OZA was 31.62° (standard deviation 6.91°, median 33° [25°; 35.25°], minimum 23°, maximum 43°), that with the TZA was 21.75° (standard deviation 6.54°, median 20.5° [15.75°; 27.25°], minimum 15°, maximum 32°), and that with the mOZA was 30.88° (standard deviation 6.66°, median 31.5° [25°; 35°], minimum 22°, maximum 42°) (Table 2).

When comparing the three most commonly used basal lateral approaches, namely, a two-flap OZA, mOZA, and TZA, we determined which of these approaches provides the maximum angles of attack depending on the location of the pathological process (Figs. 7 and 8).

When approaching targets located within the anterior cranial fossa, no significant differences were observed between vertical and horizontal angles when performing two-flap OZA and mOZA. Moreover, with the TZA compared with the two-flap OZA and mOZA, the vertical angle to the apex of the anterior clinoid process and the ICA bifurcation decreased by an average of 10°, and the horizontal angle to the apex of the anterior clinoid process decreased by an average of 21°.

When approaching structures located within the middle cranial fossa, the widest possible vertical and horizontal angles of attack are opened when performing a two-flap OZA. Comparison of the mOZA with the two-flap OZA showed no significant differences in the horizontal angles of attack to the MCA bifurcation and trigone of nerve III; on average, they were 71° and 61°, respectively. Moreover, the horizontal angle of attack with these approaches was significantly greater than the horizontal angle with the TZA, at which it averaged 58° and 44°, respectively. In contrast, when comparing the TZA with the two-flap OZA, no significant differences were found in the vertical angles of attack to the MCA bifurcation and trigone of nerve III; on average, they were 71° and 57°, respectively. Moreover, the vertical angle of attack with these approaches was significantly greater than the vertical angle with the mOZA, at which it averaged 60° and 47°, respectively.

When approaching the basilar artery apex, the greatest angles of attack are opened when performing a two-flap OZA (vertical 33°, horizontal 31°). With the TZA, opening an identical vertical angle to the basilar artery apex is possible, and a smaller horizontal angle is 21°. In turn, with the mOZA, it is possible to open the same horizontal angle to the basilar artery apex, but with a smaller vertical angle of 26°.

DISCUSSION

With a two-flap OZA, wide horizontal and vertical angles of attack are opened to targets located on both the medial base of the anterior and middle cranial fossae and the superior bifurcation site of the basilar artery. This approach is the most universal when approaching various segments of the skull base.

When the pathological process is located in the anterior cranial fossa, in the apex of the anterior clinoid process and bifurcation of the ipsilateral ICA, the maximum horizontal and vertical angles of attack are obtained when performing a two-flap OZA and mOZA. We recommend performing the mOZA to approach the structures of the anterior cranial fossa because it is less traumatic, simpler, and faster to perform than a two-flap OZA and provides the same large angles of attack for surgery.

When approaching the structures of the middle cranial fossa, a two-flap OZA and TZA provide comparable angles of attack; therefore, to access the bifurcation of the MCA or trigone of nerve III in localized, small pathological processes, the use of the TZA is sufficient because it is less traumatic and technically simpler. However, in cases where the process spreads widely in the anteroposterior direction in the medial parts of the middle cranial fossa and requires a wider horizontal viewing angle, a two-flap OZA is preferred. When performing the OZA and mOZA, large horizontal angles of attack are ensured, whereas the vertical angles of the double-flap attack are the maximum during the OZA and TZA. In our opinion, increasing the vertical angle of attack on the structures of the middle cranial fossa is more important than increasing the horizontal angle because increasing the vertical angle made it possible to reduce the traction effect on the temporal lobe. With the TZA, the vertical angle to targets located in the middle cranial fossa is comparable to that with a two-flap OZA, as both approaches equally reduce traction of the temporal lobe. However, the TZA is significantly less traumatic, simpler, and faster to perform than the two-flap OZA.

We believe that a two-flap OZA is optimal for approaching the of the basilar artery apex. When working in the basilar artery apex, a very narrow and long surgical corridor is formed with numerous important vascular and nervous structures that require careful and minimal influence. Every angle of surgical attack is important to operate safely in this field, particularly when adverse events occur during surgery.

When performing a comparative analysis of the three approaches, some aspects related to the study of quantitative characteristics of fixed anatomical specimens in the laboratory must be considered. Data obtained in the laboratory did not enable us to simulate the working conditions of a surgeon in the operating room. In addition, data obtained from various anatomical studies will not necessarily correlate with each other because of the large number of technical nuances that arise during each surgery. This is because anatomical specimens are chemically fixed, which causes differences in tissue stiffness and resistance. Second, spatial relationships are altered because of a lack of blood or cerebrospinal fluid circulation. Third, brain traction with the use of spatulas to achieve conditional goals can be maximum and nearly limitless, which cannot be repeated in the operating room. Fourth, the small number of anatomical specimens, given the variability of anatomical structures, determines the type of statistical analysis. Therefore, the angles of attack calculated in the laboratory may differ significantly from the angles that will be obtained in vivo. Moreover, this study is valuable for practicing doctors because it obtained relative data on the difference in the angles of surgical attack for three lateral basal approaches often used in the daily practice of a neurosurgeon. Based on the data obtained, the optimal choice of basal access depends on the surgeon’s tasks.

CONCLUSION

In a comparative analysis of the angles of attack after performing a two-flap OZA, mOZA, and TZA, the most universal is the two-flap OZA because it provides wide access to skull base structures in the anterior and middle cranial fossae, the interpeduncular cistern with minimal traction of the brain. The mOZA is preferred to minimize surgical trauma and the risks of complications with an isolated approach to the anterior cranial fossa, and if the pathological focus is localized in the middle cranial fossa, the TZA is recommended (if the intervention purpose allows that). To approach the basilar artery bifurcation, a two-flap OZA is optimal.

***Conflict of** interest. The authors declare no conflict of interest.*

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