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TO EVALUATE THE EFFECTIVENESS OF VARIOUS METHODS OF PLASTIC SURGERY OF POST-TRAUMATIC DEFECTS OF THE CRANIAL VAULT

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Abstract
This study presents a clinical analysis of 60 cases of post-traumatic cranial vault defects treated at the Department of Neurosurgery of Samarkand State Medical University between 2020 and 2025. The effectiveness of three reconstruction methods was compared: autologous cranioplasty using a fan-shaped titanium device, alloplastic repair using titanium mesh, and 3D computer-modeled cranioplasty using patient-specific PEEK implants. Autologous repair showed the fewest complications and best cosmetic outcomes, while PEEK implants ensured precise anatomical reconstruction and high safety. The study emphasizes the importance of individualized treatment strategies and technical resources in selecting the optimal reconstruction method.
Keywords: post-traumatic skull defect, cranioplasty, titanium mesh, fan-shaped device, 3D implant, PEEK.

Аннотация
В данной работе представлен клинический анализ 60 случаев посттравматических дефектов свода черепа, пролеченных в нейрохирургическом отделении Самаркандского государственного медицинского университета с 2020 по 2025 год. Сравнена эффективность трёх видов краниопластики: аутопластика с использованием веерообразного титанового устройства, аллопластика титановыми сетками и краниопластика индивидуальными 3D-имплантами из PEEK. Установлено, что аутопластика демонстрирует наименьшее количество осложнений и лучший косметический эффект, в то время как применение 3D-имплантов обеспечивает высокую точность и безопасность при восстановлении черепных дефектов. Работа подчёркивает важность индивидуального подхода и технической оснащённости при выборе метода пластики.
Ключевые слова: посттравматический дефект черепа, краниопластика, титановая сетка, веерообразное устройство, 3D-имплант, PEEK.

Annotatsiya
Ushbu maqolada 2020–2025 yillar oralig‘ida Samarqand davlat tibbiyot universitetining neyroxirurgiya bo‘limida davolangan bosh suyak shohidagi 60 ta travmadan keyingi suyak nuqsoni holati klinik tahlil qilingan. Kranoplastikaning uch xil usuli samaradorligi solishtirildi: bemorning o‘z suyak to‘qimasidan foydalangan holda titanli yelpig‘ichsimon qurilma bilan autoplastika, titan to‘r bilan alloplastika va PEEK moddasi asosida tayyorlangan 3D individual implantlar bilan kranioplastika. Natijalar shuni ko‘rsatdiki, autoplastika eng kam asoratlar va yaxshi kosmetik natijalarni berdi, 3D-implantlar esa nuqsonni anatomik aniqlik bilan tiklashda yuqori samaradorlik

va xavfsizlikni ta’minladi. Maqolada plastika usulini tanlashda individual yondashuv va texnik imkoniyatlarning ahamiyati alohida ta’kidlangan.

Kalit so‘zlar: travmadan keyingi suyak nuqsoni, kranioplastika, titan to‘r, yelpig‘ichsimon qurilma, 3D implant, PEEK.

Introduction. Craniocerebral trauma (CCT) is one of the most pressing problems of modern medicine, accounting for 35-40% of all injuries in peacetime. In combined injuries, the proportion of CCT reaches 70-72%. Clinical and neurological symptoms in CCT in general and in post-traumatic cranial defects in particular are very diverse. Such patients experience general cerebral, focal, vegetative-somatic symptoms, and some patients develop epileptic seizures [3,4,6]. The problem of closing post-traumatic defects and restoring the integrity of the cranial vault has worried doctors since ancient times, and active work continues to develop various methods of plastic surgery of cranial defects and search for optimal methods of graft fixation [1,2,5]. This issue has been the subject of close attention of all neurosurgeons since the establishment of neurosurgery as a separate medical discipline.

In the process of restorative treatment, complete elimination or compensation of damage is considered optimal. In the presence of a trepanation defect in patients who have suffered a severe traumatic brain injury, pathogenetic therapy should be started with its plastic closure [4,8,9].

The optimal characteristics of any fixation system include: biological inertness of the material, reliability of fixation, no displacement between the transplant and the marginal structures of the skull, ease of use, moderate cost of the structure, as well as the absence of artifacts during neuroimaging, neurophysiological and other research methods. However, to date, none of the known methods of graft fixation fully meets all these requirements [7,10,11].

The presence of a cranial vault defect, especially an extensive one, leads to the development of organic and functional disorders of the brain, as well as to hemodynamic and cerebrospinal fluid dynamics disorders. At the same time, the risk of injury to unprotected parts of the brain by external influences increases significantly [1,3,4,9].

The aim of the study is to investigate the significance of clinical and neurological symptoms and evaluate the effectiveness of using various methods of plastic surgery for post-traumatic cranial vault defects.

Material and methods. This work is based on the analysis of the results of surgical treatment of 60 patients with post-traumatic cranial vault bone defects (PTCDBS) of various localizations who were inpatients at the multidisciplinary clinic of the Samarkand State Medical University, in the neurosurgery department, in the period from 2020 to 2025.

Among the analyzed patients, men predominated - 45 people (75.0%), there were 15 women (25.0%). All patients had a history of traumatic brain injury (TBI).

The distribution of patients by cranial defect location was as follows: in the frontal-parietal region — 48.5% of patients, in the frontal-temporal region — 42.9%, in the temporo-parietal region — 56.4%, in the frontal-parietal-temporal zone — 8.6% of patients (Diagram No. 1).

By the size of cranial defects, patients were divided into 3 groups: small defects (up to 30 cm²) — 24 patients (40%), medium defects (30–60 cm²) — 32 patients (53.3%), large defects (>60 cm²) — 4 patients (6.7%) (Table 1).

Diagram 1

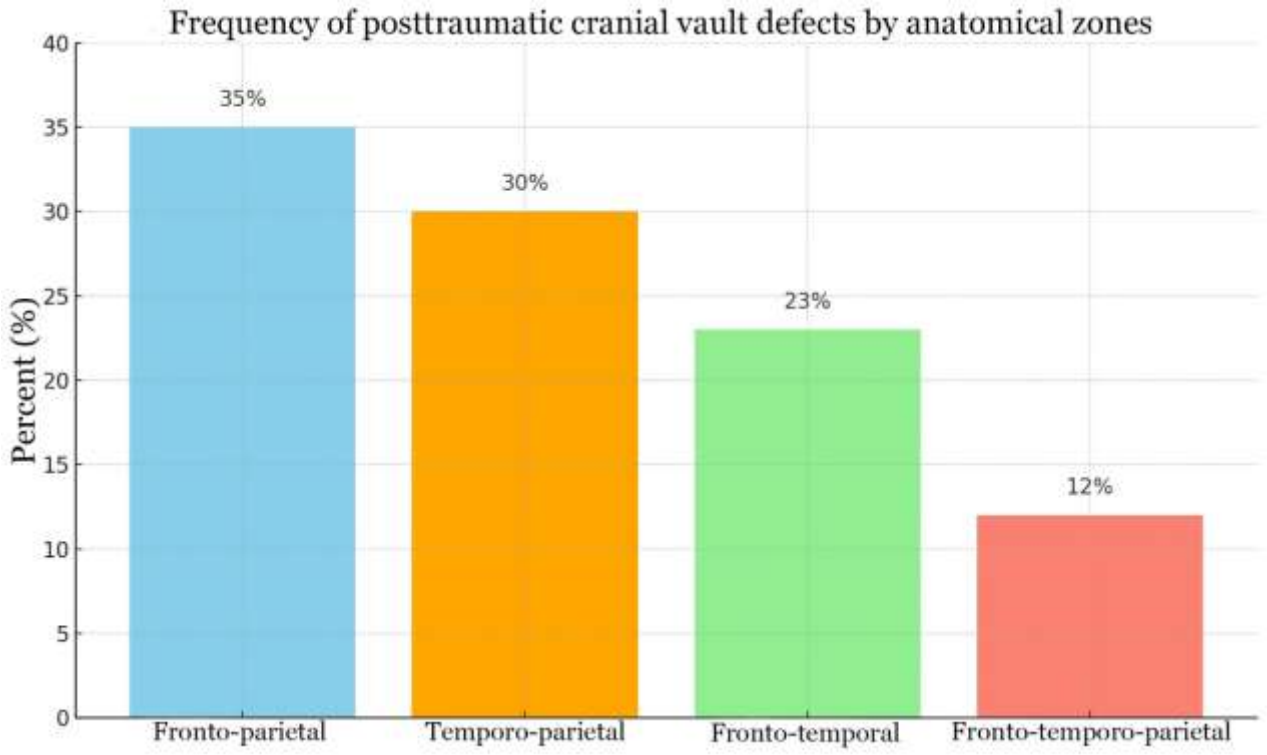


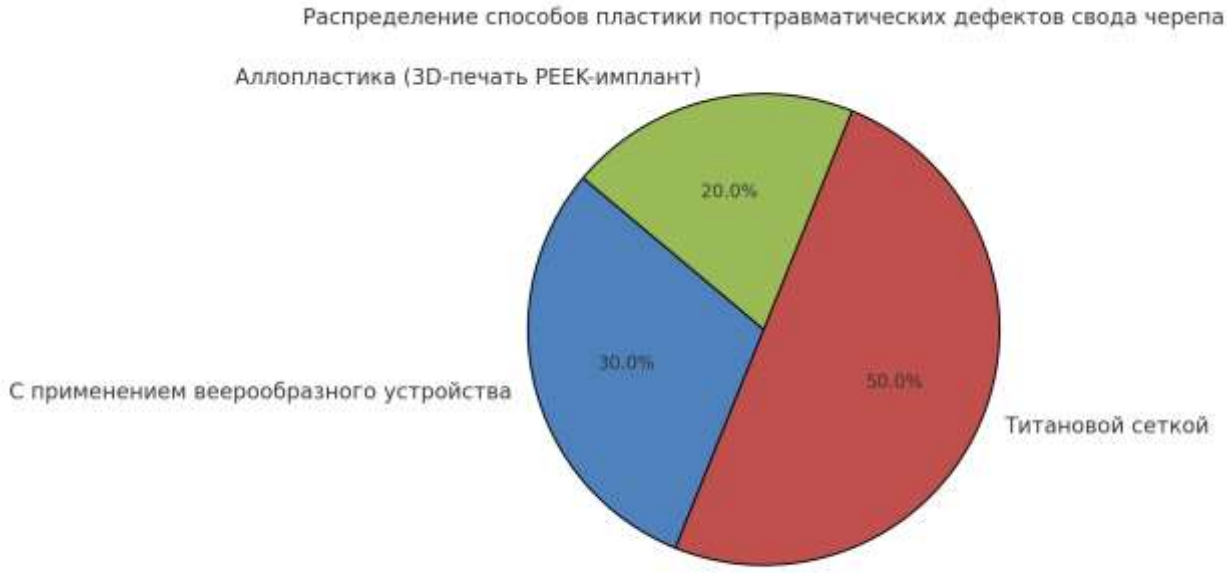
Table 1

Sizes of bone defects	Number patients	%
Small (<30 см$^{2)}$	24	40
Medium (30-60 см^2)	32	53,3
Large (>60 см^2)	4	6,7
Total	60	100

Of the 60 patients with PDKSCH, 22 (36.7%) underwent autoplasty of cranial vault bone defects using a fan-shaped titanium device, in 28 (46.7%) patients, alloplasty was performed using a titanium mesh, in 10 (16.7%) patients, alloplasty was performed using a computer modeling 3D printing PEEK (polyether-ether-ketone) implant (Diagram No. 2).

All patients underwent a comprehensive examination, including clinical, neurological, radiological with the use of modern research methods (EEG, multispiral computed tomography with 3D reconstruction of the skull and magnetic resonance imaging).

Diagram 2



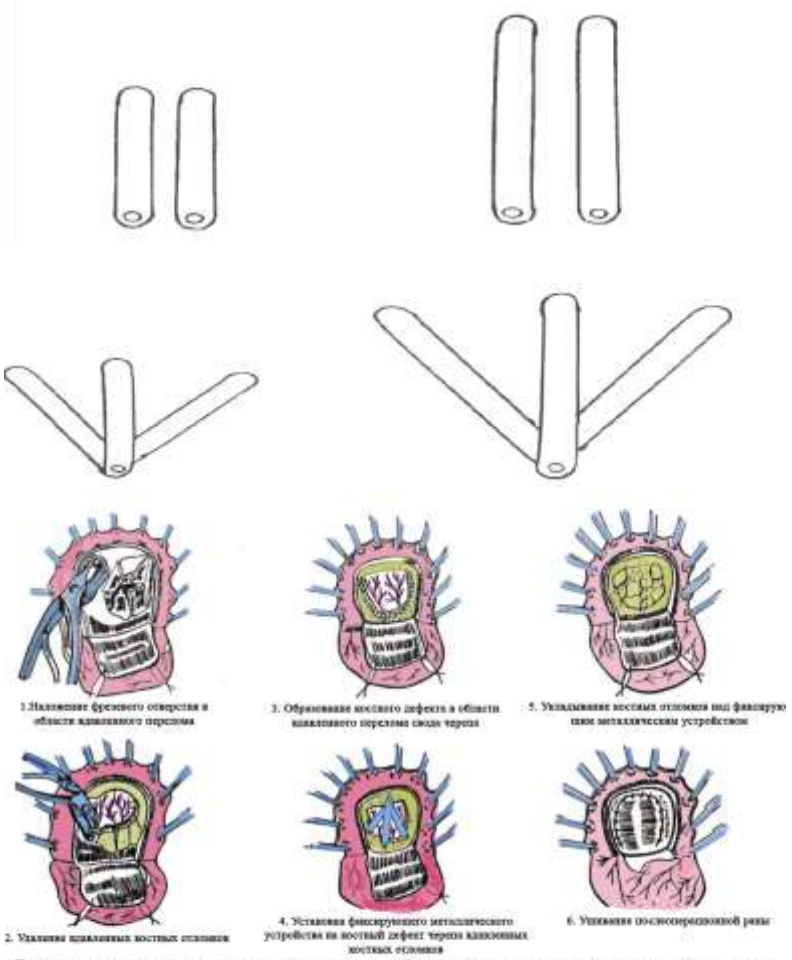
Distribution of patients by methods of cranial defect plastic surgery.

Results and discussion. In 25% of patients, cranioplasty was performed within 1 year after the injury and resection trepanation of the skull, and in the remaining 75% of patients, cranial defect plastic surgery was performed after 1 year. The neurological picture of the trepanned skull syndrome (TSS) included cephalgia (98.4%), weather instability (88.4%), decreased ability to work (47%), memory loss (72%), intellectual impairment (38%), bulging of the underlying brain tissue into the trepanation window (72%), mental changes associated with cosmetic issues and constant fear of brain injury (88%), epileptic seizures (36.8%). Focal symptoms were observed in the form of hemiparesis, central facial nerve paresis, amaurosis, hyposmia, anosmia and myopia. Hemiparesis was observed in 17.5%, central facial nerve paresis on the right in 15.4%, on the left in 12.4%, amaurosis in 5%, hyposmia in 5.6%, anosmia in 8.6% and amblyopia in 12.4%.

In post-trepanation skull defects, especially in defects after surgery for depressed cranial vault fractures and intracranial hematomas, various methods of plastic surgery are widely used: autoplasty, xenoplasty, alloplasty, etc. The best method, of course, is autoplasty of skull defects. Professor Mamadaliev A.M. et al. methods of primary and secondary autoplasty of cranial vault defects using a fan-shaped titanium device have been developed and put into practice (patents for inventions have been obtained).

In the first and second groups, the surgical intervention began with excision of the skin scar with release of the edges of the bone defect.

The fixing fan-shaped device consists of several identical titanium plates, hinged together. The ends of the plates are rounded and at one end of each plate there is a hole for mutual fixation. A stainless steel rivet used in medicine is used as a plate fixator. As an option, the hinge connection can also be carried out using stainless steel wire or thick silk. The plates have different sizes. Their length can be up to 150, width - up to 20 mm and thickness up to 2 mm. The size and number of plates depend on the size of the bone defect of the cranial vault. In the working state, the device has the shape of a "Fan". The free ends of the plates were installed in the "grooves" made between the outer and inner plates of the skull bone along the edge of the defect. The number of grooves depended on the number of plates. The hinged end of the device was placed on the opposite side of the bone defect on the made recess on the outer plates of the bone. Bone fragments removed during trepanation were evenly and tightly placed over the fan-shaped device. These fragments were prophylactically treated with an antiseptic solution. The postoperative wound was sutured tightly.



Этапы операции аутопластики дефектов свода черепа с применением вееробразного титанового устройства.

The best results were noted in autoplasty of bone defects of the cranial vault. No purulent complications were noted in these groups of patients. However, 1 of 22 patients experienced various complications after the operation, such as transplant rejection.

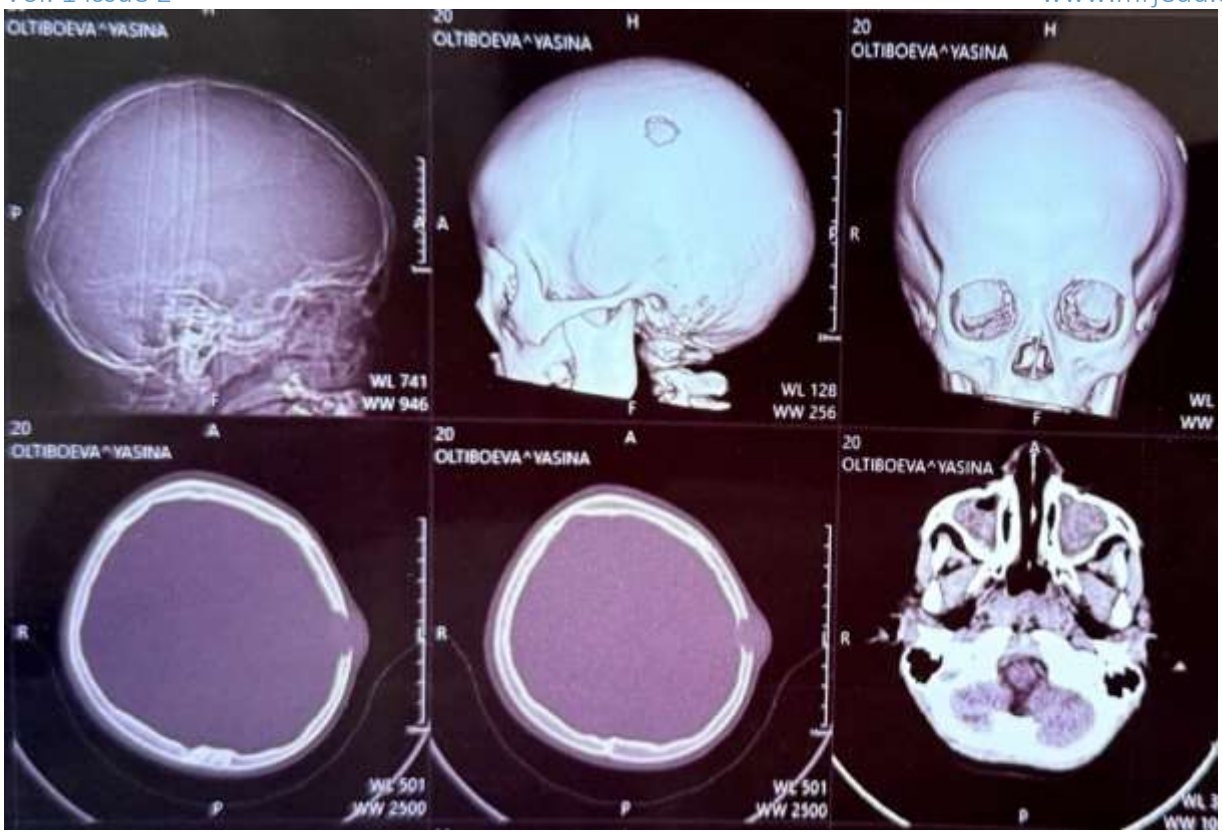


Fig. 1: MSCT examination of a patient with a depressed fracture of the left temporal bone

Fig. 2: Intraoperative photos 1,2. Installation of a FAN-shaped titanium plate

Of the 28 patients who underwent secondary allocranioplasty, 4 (14.3%) patients experienced various complications in the form of transplant rejection, suppuration of the postoperative wound and osteomyelitis of the edges of the bone defect, which ultimately required removal of the transplants.

Fig. 3: MSCT examination of a patient with a bone defect in the frontotemporo-parietal region of the cranial vault on the right

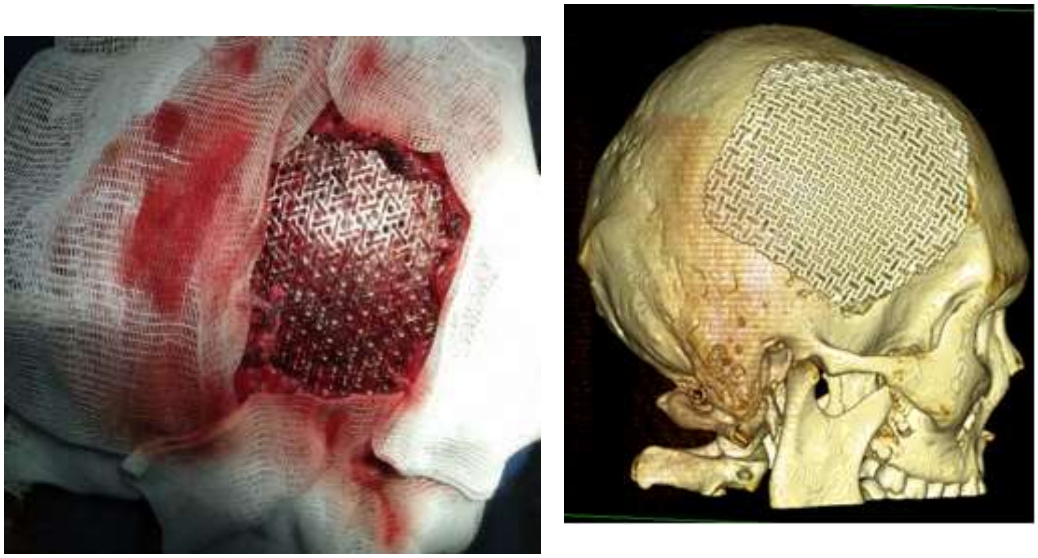
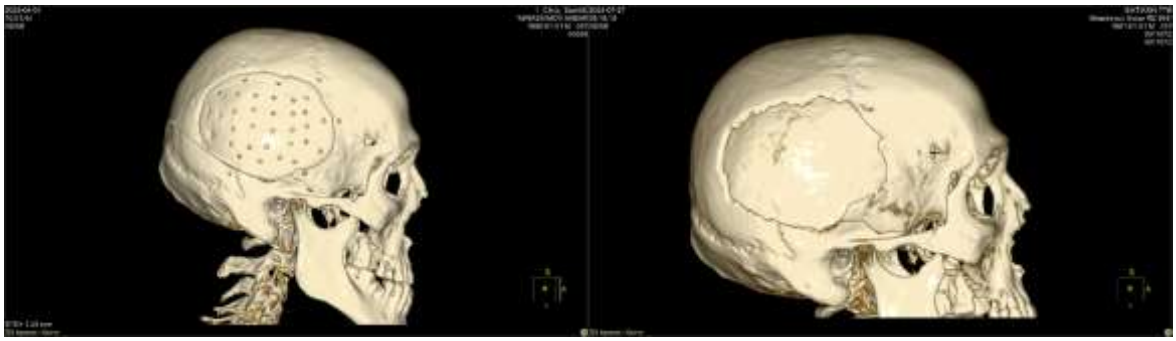


Fig. 4: Intraoperative photos (condition after installation of titanium mesh); and MSCT (after surgery) of patient B. Condition after alloplasty with titanium implant in the right frontal-parietal-temporal region.

Installed PEEK (polyether-ether-ketone) implants using 3D computer modeling technology completely restore the integrity and shape of the skull.

Of the 10 patients who underwent secondary allocranioplasty with a PEEK (polyether-ether-ketone) implant, various complications such as transplant rejection, suppuration of the postoperative wound and osteomyelitis of the edges of the bone defect were not noted, which ultimately required removal of the transplants.



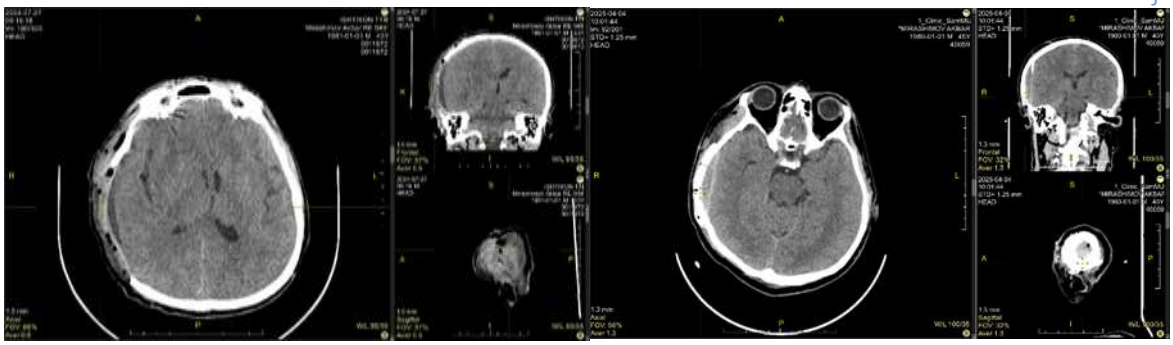


Fig. 5: MSCT examination of a patient with a bone defect in the frontal-parietal-temporal region of the cranial vault on the right., Intraoperative photos (skeletonization of the bone defect and installation of an implant).

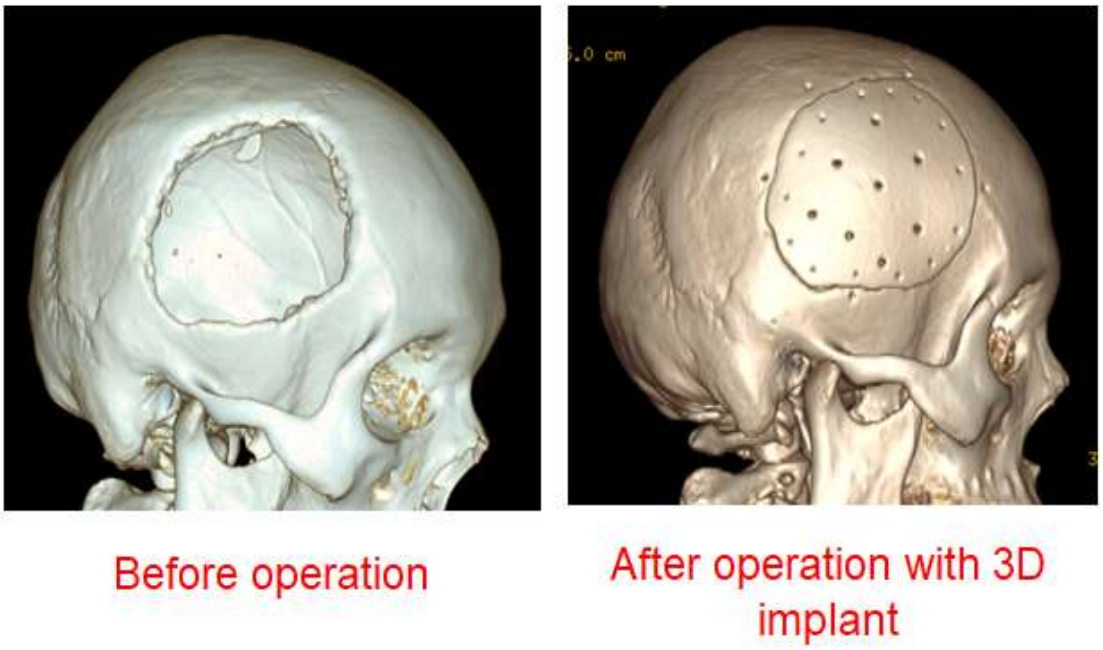


Fig. 6. 3D MSCT of patient M.A. Condition before and after surgery; Postoperative defect of the cranial vault on the right. Using 3D implants for plastic surgery of the bone defect of the cranial vault on the right.

In all cases, a satisfactory cosmetic effect was achieved. At the time of discharge, the patients had no complaints - there was no pain in the area of the transplant, the scar was soft, painless, the skin color was unchanged, there was no swelling, and the symmetry of the skull was preserved.

A follow-up examination did not reveal any deviations in the neurological status of patients in both groups. In 58 (96.7%) patients, the pain syndrome regressed. In all cases, a good cosmetic result was achieved. Upon palpation, the transplants did not differ from the surrounding bones of the patients, symmetry was preserved in all cases. Repeated craniography in patients of the first group did not reveal changes in the bone structure at the site of fixation and adjoining of the plates to the bones of the skull. Conclusions

The conducted studies have shown that the use of implants made of titanium mesh optimizes the task of eliminating complex skull defects, reduces the trauma and duration of surgery, and provides a predictable good functional and cosmetic result.

The use of computer 3D modeling allows for the closure of skull bone defects of any size and configuration, and in the postoperative period, the best cosmetic and functional results are achieved, since the designed 3D implant is maximally identical to the contours of the bone defect. The implant

is manufactured before the operation, thus significantly reducing the duration of the surgical intervention, reducing the risk of infectious complications.

The use of the autocranioplasty method using a fan-shaped fixing device in patients in the acute period of TBI and in the late period of traumatic disease with existing defects of the vault bones has shown its high efficiency. The advantage of this type of plastic surgery over others is that the patient's own bone tissue is used as a plastic material. The simplicity of the metal device, its fixation in the area of the bone defect, the ease of subsequent removal and the possibility of performing autocranioplasty in any neurosurgical hospital - all these positive qualities also showed the advantages of this method over other types of plastic surgery.

References:

1. Бельченко, В.А. Реконструкция и эндопротезирование краев и стенок глазниц, костей свода черепа, верхней и средней зон лица / В. А. Бельченко // Материалы III съезда нейрохир. Рос. - СПб., 2002. - С. 634.

2. Гайдар, Б.В. Практическая нейрохирургия: Рук. для врач. / Под ред. Б.В. Гайдара. - СПб.: Гиппократ, 2002. - 648 с.

3. Гусев, Е. И. Неврология и нейрохирургия: учебник: в 2 т. / Е. И. Гусев, А. Н. Коновалов, В. И. Скворцова; под ред. А. Н. Коновалова, А. В. Козлова. - М.: ГЭО- ТАР-Медиа, 2009. - Т. 2: Нейрохирургия. - 420 с.

4. Коновалов, А. Н. Клиническое руководство по черепно-мозговой травме / А. Н. Коновалов, Л. Б. Лихтерман, А. А. Потапов. - М., 2002. - 675 с.

5. Левченко, О. В. Современные методы краниопластики / О. В. Левченко, В. В. Крылов // Неврология. - 2009. - № 1.

6. Мамадалиев А.М., Агзамов М.К. Профилактика посттравматических арахноидитов в остром периоде тяжелой ЧМТ. Проблемы морфологии и паразитологии им. Сеченева. М. 1992. с. 296.

7. Мамадалиев, А. М. Прогнозирование исходов черепно-мозговой травмы в остром периоде. Дис. д.м.н. М. 1988.

8. Мамадалиев, А. М. Юлдашев Ш.С. Устройство для осуществления аутопластики дефектов свода черепа. Проблемы медицины. Тезисы докладов научной конференции, посвященной 600-летию М. Улугбека. Самарканское отд. АН РУЗ. мед. отдел. 1994. –с. 41-42.

9. Мамадалиев, А. М. Юлдашев Ш. С. Устройство для аутопластики дефектов свода черепа. Патент на изобретение Российской федерации N2050833 от 27 декабря 1995 года.

10. Мамадалиев А.М., Юлдашев Ш.С. Результаты первичной аутопластики при вдавленных переломах свода черепа. Тезисы докладов 1-съезда нейрохирургов Российской Федерации. Екатеринбург. 1995.

11. Мамадалиев А.М., Шахнович А.Р., Абакумова Л.Я. Прогностическое значение количественной оценки нарушения сознания в динамике. Мед. журнал Узбекистана. 1987. № 6.-с. 18- 22.

12. Потапов, О. О. Досвщ сучасного закриття дефекпв исток черепа / О. О. Потапов, О. П. Дмитренко, О. П. Кмита // IV Съезд нейрохирургов Украины: тез. докл.Д., 2008. - С. 23.

13. Tanaka, Y. Development of titanium fixation screw for hydroxyapatite osteosynthesis (APACERAM) / Y. Tanaka // Surg neurol. - 2008. - Vol. 70, № 5.- P. 545-549.

14. Wilkinson, H. A. Cranial bone fixation / H. A. Wilkinson // J. Neurosurg. - 2004. - Vol. 100, № 6. - P.l 134-1135.

15. Sahoo N, Tomar K, Thakral A, Rangan N. Complications of Cranioplasty. J Craniofac Surg. 2018 Jul;29(5):1344-1348. doi: 10.1097/SCS.0000000000004478.

16. Thawani J.P., Pisapia, J.M., Singh, N., Petrov, D., Schuster, J.M., Hurst, R.W., Zager, E.L., Pukenas, B.A., 2016. 3D-Printed Modeling of an Arteriovenous Malformation Including Blood Flow., World neurosurgery. Elsevier Inc. doi:10.1016/j.wneu.2016.03.095

17. Yeap MC, Tu PH, Liu ZH, Hsieh PC, Liu YT, Lee CY, Lai HY, Chen CT, Huang YC, Wei KC, Wu CT, Chen CC. Long-Term Complications of Cranioplasty Using Stored Autologous Bone Graft, Three-Dimensional Polymethyl Methacrylate, or Titanium Mesh After Decompressive Craniectomy: A Single-Center Experience After 596 Procedures. World Neurosurg. 2019 May 10. pii: S1878-8750(19)31279-3. doi: 10.1016/j.wneu.2019.05.005.

18. Zanaty M, Chalouhi N, Starke RM, Clark SW, Bovenzi CD, Saigh M, Schwartz E, Kunkel ES, Efthimiadis-Budike AS, Jabbour P, Dalyai R, Rosenwasser RH, Tjoumakaris SI. Complications following cranioplasty: incidence and predictors in 348 cases. J Neurosurg. 2015 Jul;123(1):182-8. doi: 10.3171/2014.9.JNS14405.

19. Zanotti B, Zingaretti N, Verlicchi A, Robiony M, Alfieri A, Parodi PC. Cranioplasty: Review of Materials. J Craniofac Surg. 2016 Nov;27(8):2061-2072. doi: 10.1097/SCS.0000000000003025.

20. Stula D. The problem of the “sinking skin-flap syndrome” in cranioplasty //Journal of maxillofacial surgery. - 1982. - T. 10. - C. 142-145.

21. Zegers, T., ter Laak-Poort, M., Koper, D., Lethaus, B., & Kessler, P. (2017). The therapeutic effect of patient-specific implants in cranioplasty. Journal of Cranio-Maxillofacial Surgery, 45(1), 82-86.