Оригинальное исследование | Original study article
DOI: https://doi.org/10.35693/SIM643139

Maxillary reconstruction using the "Autoplan" software suite

Vladimir Yu. Ivashkov[1], Aleksandr S. Denisenko[1], Aleksandr V. Kolsanov[1], Elena V. Verbo[2], Andrei N. Nikolaenko[1], Aleksandr Yu. Legonkikh[1]

[1]Samara State Medical University (Samara, Russian Federation)
[2]Russian Medical Academy of Continuous Professional Education (Moscow, Russian Federation)

Abstract

Aim – to develop a three-stage algorithm for maxillary reconstruction with the Autoplan software suite to improve the results of surgical treatment.

Material and methods. 110 patients with maxillary defects were included in the study and were divided into the main (60) and control (50) groups. The three-stage algorithm and the Autoplan software suite were used to perform reconstructive procedures only in the main group. All the postoperative results were assessed in a period of six months after the surgery.

Results. Good aesthetic result was noted in 29 (48.33%) cases in the main group and in 17 (34%) cases in the control group (p<0.001). The differences between the main and control groups in functional results are statistically significant (p<0.05): good speech quality: 31 (86.11%) in the main group, 22 (78.57%) in the control group (p=0,047). Diet without limitations: main group, 26 cases (72.22%), control group, 18 cases (64.29%) (p=0,042). The mean time of the reconstructive stage using scapular flap: main group, 210 (35) minutes, control group, 300 (35) minutes (time reduction by 30 (13.4)%; fibular flap: main group, 180 (16) minutes, control group, 260 (36) minutes (time reduction by 30.77 (11.2)%; ALT flap: main group, 175 (17) minutes, control group, 220 (33) minutes (time reduction by 20.45 (13.3)%; radial flap: main group, 130 (12) minutes, control group, 170 (12) minutes (time reduction by 23.53 (8.1)% (p<0,001).

Conclusion. It can be concluded that incorporation of additive technologies, personalized attachment systems, and preoperative planning are crucial components of contemporary reconstructive surgery. This approach not only helps to streamline surgical procedures but also contributes to favorable functional and aesthetic outcomes.

Keywords: maxillary reconstruction, mandible reconstruction, additive technologies, microsurgery, autologous flaps, facial reconstruction.

Conflict of interest: nothing to disclose.

Citation
Ivashkov VYu, Denisenko AS, Kolsanov AV, Verbo EV, Nikolaenko AN, Legonkikh AYu. **Maxillary reconstruction using the "Autoplan" software suite.** *Science and Innovations in Medicine*. 2025;10(1):75-80. DOI: https://doi.org/10.35693/SIM643139

Information about authors
Vladimir Yu. Ivashkov – MD, Cand. Sci. (Medicine), Chief Scientific Advisor of the NTI Center for Bionic Engineering in Medicine.
ORCID: 0000-0003-3872-7478
E-mail: v.yu.ivashkov@samsmu.ru
Aleksandr S. Denisenko – Resident of the Department of Plastic Surgery.
ORCID: 0000-0002-6791-2237
E-mail: allexander.pafem@gmail.com
Aleksandr V. Kolsanov – MD, Professor of the Russian Academy of Sciences, Rector.
ORCID: 0000-0002-4144-7090
E-mail: a.v.kolsanov@samsmu.ru
Elena V. Verbo – MD, Dr. Sci. (Medicine), Professor of the Department of Plastic and Maxillofacial Surgery.
ORCID: 0000-0001-9843-5026
E-mail: plasticrmapo@gmail.com
Andrei N. Nikolaenko – MD, Dr. Sci. (Medicine), Director of the Research Institute of Bionics and Personalized Medicine.
ORCID: 0000-0003-3411-4172
E-mail: a.n.nikolaenko@samsmu.ru
Aleksandr Yu. Legonkikh – MD, plastic surgeon.
ORCID: 0009-0005-3259-547X
E-mail: aleksandr.mox.fox@gmail.com

Corresponding Author
Aleksandr S. Denisenko
Address: 9th Severnaya Line, 17, apt. 123, Moscow, Russia, 127204.
E-mail: allexander.pafem@gmail.com

Received: 17.12.2024
Accepted: 28.01.2025
Published: 05.02.2025

Устранение дефектов верхней челюсти с применением трехэтапного алгоритма и программного комплекса «Автоплан»

В.Ю. Ивашков[1], А.С. Денисенко[1], А.В. Колсанов[1], Е.В. Вербо[2], А.Н. Николаенко[1], А.Ю. Легоньких[1]

[1]ФГБОУ ВО «Самарский государственный медицинский университет» Минздрава России (Самара, Российская Федерация)
[2]ФГБОУ ДПО «Российская медицинская академия непрерывного профессионального образования» Минздрава России (Москва, Российская Федерация)

Аннотация

Цель – разработать и внедрить трехэтапный алгоритм устранения дефектов верхней челюсти с программным комплексом «Автоплан» для улучшения результатов хирургического лечения.

Материал и методы. В исследовании приняли участие 110 пациентов с приобретенными дефектами верхней челюсти, которых разделили на основную (60 человек) и контрольную (50 человек) группы. Алгоритм, состоящий из трех этапов, и программный комплекс «Автоплан» применялись для выполнения реконструктивно-пластических операций только в основной группе. Оценка послеоперационных результатов производилась через 6 месяцев после операции и включала следующие параметры: функциональный результат, эстетический результат, временные затраты на оперативное вмешательство.

Результаты. В основной группе хороший эстетический результат был достигнут в 29 (48,33%) случаях, в контрольной – в 17 (34%) случаях (p<0,001). Различия между основной и контрольной группами по функциональным результатам статистически значимы (p<0,05). Хорошее качество речи было получено в основной группе в 31 (86,11%) случае, в контрольной группе – в 22 (78,57%) случаях (p=0,047). Диета без ограничений в основной группе отмечалась в 26 (72,22%) случаях, в контрольной – в 18 (64,29%) случаях (p=0,042). Среднее время реконструктивного этапа с применением лопаточного лоскута в основной группе составило 210 (35) минут, в контрольной – 300 (35) минут (сокращение времени на 30 (13,4)%); с применением малоберцового лоскута в основной группе составило 180 (16) минут, в контрольной – 260 (36) минут (сокращение времени на 30,77 (11,2)%; с применением ALT-лоскута в основной группе 175 (17) минут, в контрольной группе 220 (33) минут (сокращение времени на 20,45 (13,3)%; с применением лучевого лоскута в основной группе составило 130 (12) минут, в контрольной – 170 (12) минут (сокращение времени на 23,53 (8,1)% (p<0,001).

Выводы. Применение аддитивных технологий, индивидуализированных систем фиксации и предоперационного планирования является неотъемлемой частью современной реконструктивной хирургии, что на практике позволяет сократить время операции, а также получать хорошие функциональные и эстетические результаты в большем количестве случаев по сравнению с общепринятыми методиками.

Ключевые слова: реконструкция верхней челюсти, реконструкция нижней челюсти, аддитивные технологии, микрохирургия, аутологичные лоскуты, устранение дефектов лица.

Конфликт интересов: не заявлен.

Для цитирования:
Ивашков В.Ю., Денисенко А.С., Колсанов А.В., Вербо Е.В., Николаенко А.Н., Легоньких А.Ю. **Устранение дефектов верхней челюсти с применением трехэтапного алгоритма и программного комплекса «Автоплан».** *Наука и инновации в медицине.* 2025;10(1):75-80. DOI: https://doi.org/10.35693/SIM643139

Сведения об авторах

Ивашков В.Ю. – канд. мед. наук, главный научный консультант Центра НТИ «Бионическая инженерия в медицине».
ORCID: 0000-0003-3872-7478
E-mail: v.yu.ivashkov@samsmu.ru

Денисенко А.С. – клинический ординатор кафедры пластической хирургии.
ORCID: 0000-0002-6791-2237
E-mail: allexander.pafem@gmail.com

Колсанов А.В. – профессор РАН, д-р мед. наук, профессор, ректор.
ORCID: 0000-0002-4144-7090
E-mail: a.v.kolsanov@samsmu.ru

Вербо Е.В. – д-р мед. наук, профессор кафедры пластической и челюстно-лицевой хирургии.
ORCID: 0000-0001-9843-5026
E-mail: plasticrmapo@gmail.com

Николаенко А.Н. – д-р мед. наук, директор НИИ бионики и персонифицированной медицины.
ORCID: 0000-0003-3411-4172
E-mail: a.n.nikolaenko@samsmu.ru

Легоньких А.Ю. – врач – пластический хирург.
ORCID: 0009-0005-3259-547X
E-mail: aleksandr.mox.fox@gmail.com

Автор для переписки
Денисенко Александр Сергеевич
Адрес: Линия 9-я Северная, 17, кв. 123, г. Москва, Россия, 127204.
E-mail: allexander.pafem@gmail.com

Получено: 17.12.2024
Одобрено: 28.01.2025
Опубликовано: 05.02.2025

INTRODUCTION

Modern facial injuries caused by new types of weapons, increased vehicle speeds, and diagnosed malignancies pose a serious surgical challenge. According to statistics, the number of facial injuries has more than doubled over the past decade[1].

Injuries resulting from a variety of impact mechanisms result in multiple injuries to both soft and hard facial tissues. For example, fractures of the upper jaw are often combined with eye socket injuries and damage to the soft tissues of the face [1]. This requires a comprehensive approach to treatment, including surgical intervention and restorative therapy.

With respect to defects of the maxilla, the main tasks are the elimination of oronasal fistula, restoration of the lower wall of the orbit to ensure the supporting function of the eyeball, restoration of the functions of chewing, swallowing, breathing, speech, as well as the implementation of complete dental rehabilitation.

An important practical area is the customization of surgical interventions based on the patient's anthropometric data. Taking into account the unique anatomical features of the patient ensures good functional and aesthetic results, which opens up new horizons for the successful rehabilitation of patients with complex facial defects [2].

There are numerous classifications of maxillary defects. One of the latest is the classification of J.S. Brown (2010), based on the identification of the vertical and horizontal components of the defect. Depending on the presence of the anastomosis between the oral and the nasal cavity, involvement of the supporting structures of the eye socket in the defect, the scope of damage of the hard palate and some other parameters, the authors suggested six types of defects [3].

Today's clinical practices place more importance on the customized approach, modern systems of visualization, surgery planning combined with involvement of additive technologies. 3D-modeling enables reproduction of precise stereolithographic models on the stage of planning of reconstruction based on the patient's anthropometric data [4]. The use of individual templates provides the possibility of reaching high precision of congruence of the bony surfaces of the flap and recipient wound, reducing surgery time and yielding better functional and aesthetic results of reconstructive plastic surgery [5, 6].

AIM

To develop a three-stage algorithm for maxillary reconstruction with the Autoplan software suite to improve the results of surgical treatment.

[1]Federal Service of State Statistics: traumatism statistics in Russia. Available online: https://rusind.ru/statistika-travmatizma-v-rossii-po-rosstatu.html

MATERIAL AND METHODS

A randomized controlled trial was conducted involving 110 patients with maxillary defects of post-traumatic and post-oncological etiology. The participants of the study were divided into two groups, the main and the control group. The main group included 60 people, average age of 46±11 years, men to women ratio: 46/14. The control group included 50 people, average age of 47±12 years, men to women ratio: 39/11.

In accordance with the J.S. Brown's classification of maxillary defects (2010), four types of defects were identified (Type I-IV).

Type I: lower combined defects of the maxilla, predominantly with a horizontal component, affecting the mucous membrane of the retromolar region, the soft palate region and the lateral wall of the oropharynx (main group: 23 patients; control group: 16 patients).

Type II: defects resulting from total maxillectomy (main group: 13 patients; control group: 12 patients).

Type III: partial defect of the maxilla, predominantly with a vertical component (main group: 15 patients; control group: 13 patients).

Type IV: inclusion of the orbit with its exenteration (main group: 9 patients; control group: 9 patients).

In the main group of patients with combined maxillary defects, the surgery planning, performance and follow-up involved a three-stage algorithm and the Autoplan software suite. In the control group, surgery was performed under conventional methods.

Surgery algorithm. The algorithm used to perform the surgery in the main group consisted of three stages. The first stage is preoperative planning: the patient's head CT data was uploaded to the Autoplan software suite. 3D-model of bony structure and soft tissue is constructed automatically; the defect is visualized and localized, its scope and area were calculated. For plastic material, four types of free surgical flaps were used: maple seed-shaped fasciocutaneous radial flap [7], chimeric scapular flap, ALT-flap (anterolateral thigh), and fibula flap. The selection of the suitable plastic material was performed in the automatic flap selection program[1], based on the following parameters: area, scope and composition of the defect, necessity of cavity plugging. If the selected flap was fibular or scapular, additional CT was performed of the lower leg or the scapular region, respectively. The data was uploaded to the Autoplan software suite, where the 3D model of the flap was constructed with fitting in the defect area. This stage also included construction of 3D models and construction of individual templates for resection, flap modeling and fixation system.

The second stage is the surgery. During the surgery, individual templates for re-resection were used to refresh the bonesaw lines of the recipient area, isolation and modeling of the flap were performed using individual templates and fixation system with retained blood flow in the autogenetic graft.

In the third stage, the modeled flap was repositioned to the recipient area and partially attached to the bonesaw lines of bony structures. Microsurgery was then performed to form the anastomoses with subsequent final fixation of the flap and suture of the wound.

The postoperative results in both groups were assessed six months after the operation. The criteria studied were the results of the functional (binocular vision, dietary restrictions, speech disorders) and aesthetic aspects; the amount of time spent on the surgical stage; the incidence of post-surgery complications. For each of the parameters, the functional result was assessed as 'good', 'satisfactory', or 'poor'. The aesthetic results were assessed using the FACE-Q scales, depending on the score, the 'good' (≥80 points), 'satisfactory' (65-79 points), 'poor' (≤64 points) evaluations were given.

Data processing. Using descriptive statistics, mean values and standard deviations were obtained. Statistical tests were used to determine the statistically significant $\alpha < 0{,}05$ difference between the values in the control and the main groups. To assess the significance of differences between groups, Student's T-test and Pearson's χ^2 were used. IBM SPSS Statistics 23 software suite was used for statistical calculations.

RESULTS

Reconstructive plastic surgeries were performed on 110 patients with defects of the upper jaw (N=60 in the main group, N=50 in the control group). The autogenetic graft used in the main group were distributed as follows: 22 – radial flap, 22 – ALT-flap, 14 – scapular flap, and 2 – fibula flap. The autogenetic graft used in the control group were distributed as follows: 17 – radial flap, 20 – ALT-flap, 12 – scapular flap, and 1 – fibular flap (**Table 1**).

Flap type	Type I		Type II		Type III		Type IV		Total		TOTAL
	O	K	O	K	O	K	O	K	O	K	O+K
Fibular	2 (66.7%)	1 (33.3%)	—	—	—	_	—	_	2 (66.7%)	1 (33.3%)	3 (2.7%)
Scapular	4 (15.4%)	3 (11.5%)	10 (38.5%)	9 (34.6%)	—	_	—	_	14 (53.8%)	12 (46.2%)	26 (23.6%)
ALT-flap	4 (9.5%)	3 (7.1%)	3 (7.1%)	3 (7.1%)	6 (14.3%)	5 (11.9%)	9 (21.4%)	9 (21.4%)	22 (52.4%)	20 (47.6%)	42 (38.2%)
Radial flap	13 (33.3%)	9 (23%)	—	_	9 (23%)	8 (20.5%)	—	_	22 (56.4%)	17 (43.6%)	39 (35.5%)
Total:	23 (20.9%)	16 (14.5%)	13 (11.8%)	12 (10.9%)	15 (13.6%)	13 (11.8%)	9 (8.2%)	9 (8.2%)	60 (54.5%)	50 (45.5%)	110 (100%)

Table 1. *Plastic material used for maxillary reconstruction in the main and control groups. O – main group, K – control group*

Таблица 1. *Аутотрансплантаты, примененные для реконструкции верхней челюсти в основной и контрольной группе. О – основная группа, К – контрольная группа*

[1]Certificate of state registration of the computer program: RUS №2024617819 dated 05.04.2024.
Available online: https://fips.ru/registers-doc-view/fips_servlet?DB=EVM&DocNumber=2024617819&TypeFile=html

Defect Type	TypeI (N=23)	TypeII (N=13)	TypeIII (N=15)	TypeIV (N=9)	TOTAL	P
Speech quality					N=36	p=0.047
Good	21 (91.3%)	10 (76.92%)	-		31 (86.11%)	
satisfactory	2 (8.7%)	1 (7.69%)	-		3 (8.33%)	
Poor	-	2 (15.38%)	-		2 (5.56%)	
Diet			-		N=36	p=0.042
No restrictions	19 (82.61%)	7 (53.85%)	-		26 (72.22%)	
Strained food	4 (17.39%)	5 (38.46%)	-		9 (25%)	
Liquid diet		1 (7.69%)	-		1 (2.78%)	
Aesthetic result					N=60	(p<0.001)
Good	18 (78.26%)	7 (53.85%)	4 (26.67%)		29 (48.33 %)	
satisfactory	4 (17.39%)	3 (23.08%)	9 (60%)	9 (100%)	25 (41.67 %)	
Poor	1 (4.35%)	3 (23.08%)	2 (13.33%)		6 (10%)	
Eyeball position					N=28	p=0.032
symmetrical	-	10 (76.9%)	13 (86.67%)		23 (82%)	
diplopia	-	2 (15.4%)	2 (13.33%)		4 (14%)	
enophthalm	-	1 (7.7%)	0		1 (4%)	

Таблица 2. *Функциональные и эстетические результаты устранения дефектов верхней челюсти у пациентов основной группы*
Table 2. *Functional and aesthetic results of maxillary reconstruction in the main group*

Assessment of aesthetic results. Before the surgery the average score as per the FACE-Q questionnaire was similar in both groups and was 51 points (with quartiles: Q1 - 45, Q2 - 51, Q3 - 57). The assessment 6 months after the surgery yielded the following average scores: in the main group, 79 points (Q1 - 74, Q2 - 79, Q3 - 93); in the control group, 67 points (Q1 - 64, Q2 - 67, Q3 - 80) (p<0.001). God aesthetic results were achieved in 29 (48.33%) patients of the main group and in 17 (34%) patients of the control group. Satisfactory results: 25 (41.67%) patients of the main group;21 (42%) patients of the control group. Poor results: 6 (10%) patients of the main group and 12(24%) patients of the control group.

Assessment of functional results. Speech: good quality of speech was seen in 31 (86.11%) patients of the main group and 22 (78.57%) patients of the control group; satisfactory, in 3 (8.33%) / 3 (10.71%) patients; poor, in 2 (5.56%) / 3 (10.71%) patients, respectively (p<0.05, p=0.047).

Diet. Of the 36 patients of the main group and 28 patients of the control group with maxillary defects of Type I and Type II, for 26 (72.22%) / 18 (64.29%) patients there were no dietary restrictions; 9 (25%) / 8 (28.57%) patients required strained food; 1 (2.78%) / 2 (7.14%) patients required a fluid diet (p<0.05, p=0.042).

Visual acuteness and eye position. Decrease in visual acuteness was not identified at all. In the group of patients with Type II and Type III defects (N=28 / 25) symmetry in the eyeball position was achieved in 23 (82%) / 17 (68%) of the cases; moderate diplopia was seen in 4 (14%) / 7 (28%) of the cases; enophthalmos was seen in 1 (4%) /1 (4%) of the cases, respectively (p<0.05, p=0.032).

Thus, the implementation of the three-stage algorithm allowed achievement of good functional and aesthetic results in the greater number of cases. The differences between the main and the control group are statistically significant (p<0.05) (**Tables 2, 3**).

The time required to perform the reconstructive stage of the surgery, depending on the selected graft, is shown in Table 4. Scapular flap: in the main group, the average time was 210 (35) minutes, in the control group, 300 (35) minutes (time reduced by 30 (13.4)%). Fibular flap: 180 (16) min / 260 (36) min (time reduced by 30.77 (11.2)%).

Defect Type	TypeI (N=16)	TypeII (N=12)	TypeIII (N=13)	TypeIV (N=9)	TOTAL
Speech quality					N=28
Good	13 (81.25%)	9 (75%)	-		22 (78.57%)
satisfactory	2 (12.5%)	1 (8.33%)	-		3 (10.71%)
Poor	1 (6.25%)	2 (16.67%)	-		3 (10.71%)
Diet			-		N=28
No restrictions	12 (75%)	6 (50%)	-		18 (64.29%)
Strained food	4 (75%)	4 (33.33%)	-		8 (28.57%)
Liquid diet		2 (16.67%)	-		2 (7.14%)
Aesthetic result					N=50
Good	10 (62.5%)	5 (41.67%)	2 (5.38%)		17(34%)
satisfactory	4 (25%)	3 (25%)	6 (46.15%)	8 (88.89%)	21 (42%)
Poor	2 (12.5%)	4 (33.33%)	5 (38.46%)	1 (11.11%)	12 (24%)
Eyeball position					N=25
symmetrical	-	7 (58.33%)	10 (76.92%)		17 (68%)
diplopia	-	4 (33.33%)	3 (23.08%)		7 (28%)
enophthalm	-	1 (8.33%)	0		1 (4%)

Table 3. *Results of surgical treatment of patients with maxillary defects in the control group*
Таблица 3. *Функциональные и эстетические результаты устранения дефектов верхней челюсти у пациентов контрольной группы*

	Main group				Control group			
Flap type	Angle of scapula	Fibular	ALT	Radial	Angle of scapula	Fibular	ALT	Radial
Surgery time, min	500 (52)	475 (78)	390 (65)	290 (56)	610 (66)	580 (74)	450 (71)	330 (67)
Flap modeling time, min	90 (12)	75 (13)	85 (8)	30 (4)	180 (57)	160 (24)	120 (8)	70 (6)
Reconstructive stage time, min	210 (33)	180 (15)	175 (16)	130 (12)	300 (33)	260 (34)	220 (32)	170 (11)

Table 4. *Mean surgery time in the main and control groups*
Таблица 4. *Среднее время оперативного вмешательства в основной и контрольной группах*

ALT flap: 175 (17) min / 220 (33) min (time reduced by 20.45 (13.3)%). Radial fasciocutaneous flap: 130 (12) min / 170 (12) min (time reduced by 23.53 (8.1%). The differences both in the average time of reconstructive stage and in the total time of the surgery in the main and the control group are significant (p<0.001).

DISCUSSION

The region of the head and the neck is crucial in the functions of chewing, swallowing, breathing, and speech; moreover, it is vital for social interactions. Aesthetic and functional facial defects are detrimental to the patient's quality of life [8], therefore, their repair is required for medical reasons [9-11].

To repair the defects in the middle region of the face and the maxilla, removable exoprostheses are usually used that isolate the oral and the nasal cavities, thus restoring the speech and the swallowing functions. The prosthesis may include dental elements that contribute to a satisfactory aesthetic result. One of the major advantages of this method is fast achievement of the desired result, a shorter and less invasive plan of surgical treatment without the lengthy period of rehabilitation.

In patients undergoing cancer treatment, prostheses provide the possibility of direct visual control, but given the availability of modern imaging techniques, this potential advantage has not been confirmed [12]. In addition, prostheses require daily care and must be removed and cleaned regularly, which can be a major problem for older people or those with visual impairments. In some cases, the exoptostheses may be an acceptable method for the repair of maxillary defects; however, their use can not restore the functions as effectively as the free autogenetic graft can [13].

Scientific literature currently describes a considerable number of microsurgical methods to repair the maxillary defects, including the rib osteo-cutaneous flap [14], latissimus dorsi muscle-cutaneous flap [15], scapular flap [16], rectus abdominis muscle flap [17], osseous radial flap [18], fibular flap [19, 20], and some others [21-23]. The use of the method we propose allows achievement of better functional and aesthetic results in comparison with other methods [24, 25].

Additive technologies allow achieving higher rates of bone surface congruence and reducing surgery time [26].

The three-stage algorithm of reconstructive plastic surgery proposed by us for patients with facial defects allows reducing the surgery time by 17.4% in comparison with conventional techniques. E.g., B. Barton et al. (2022) report that the time for reconstruction of the maxilla with the flap involving the scapular angle is 600 minutes [27]. In fact, this aligns with the time of surgery in the control group of our study (610 minutes), whereas in the main group, where the three-stage algorithm and the Autoplan software suite were used, the average time of surgery was reduced to 500 minutes.

The use of standardized algorithms for constructing a patient's surgical treatment trajectory helps to improve the reproducibility of such complex operations [28, 29].

CONCLUSION

We propose an approach that includes three stages of reconstructive plastic surgeries for patients with facial defects. It allows achieving better results of surgical treatment, reducing the time of surgical intervention and getting fewer complications in comparison with conventional approaches. We also believe that the presented method will reduce the time required for training of surgeons in this area.

ADDITIONAL INFORMATION	ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ
Study funding. The study was the authors' initiative without external funding.	***Источник финансирования.*** Работа выполнена по инициативе авторов без привлечения финансирования.
Conflict of interest. The authors declare that there are no obvious or potential conflicts of interest associated with the content of this article.	***Конфликт интересов.*** Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с содержанием настоящей статьи.
Compliance with Ethical Standards. The authors confirm that the rights of the people who participated in the study were respected, including obtaining informed consent. The study protocol was approved by the local Ethics Committee (protocol No. 156863 dated 20.10.2024).	***Соответствие нормам этики.*** Авторы подтверждают, что соблюдены права людей, принимавших участие в исследовании, включая получение информированного согласия. Протокол исследования был одобрен ЛЭК (протокол № 156863 от 20.10.2024 г.).
Contribution of individual authors. V.Yu. Ivashkov, A.V. Kolsanov: design of the study, scientific editing. E.V. Verbo, A.N. Nikolaenko: scientific editing. A.S. Denisenko, A.Yu. Legonkikh: review of publications on the article topic, writing of the article, collection and processing of the material. All authors gave their final approval of the manuscript for submission, and agreed to be accountable for all aspects of the work, implying proper study and resolution of issues related to the accuracy or integrity of any part of the work	***Участие авторов.*** В.Ю. Ивашков, А.В. Колсанов – создание дизайна исследования, научное редактирование; Е.В. Вербо, А.Н. Николаенко – научное редактирование. А.С. Денисенко, А.Ю. Легоньких – обзор публикаций по теме статьи, написание текста статьи, сбор и обработка материала. Все авторы одобрили финальную версию статьи перед публикацией, выразили согласие нести ответственность за все аспекты работы, подразумевающую надлежащее изучение и решение вопросов, связанных с точностью или добросовестностью любой части работы.

REFERENCES / ЛИТЕРАТУРА

1. Lalloo R, Lucchesi L, Bisignano C, et al. Correction: Epidemiology of facial fractures: incidence, prevalence and years lived with disability estimates from the Global Burden of Disease 2017 study. *Inj Prev.* 2023;29(1):e1. DOI: 10.1136/injuryprev-2019-043297

2. Verbo EV, Butsan SB, Gileva KS. *Reconstructive facial surgery. Modern methods and principles.* M., 2022. (In Russ.). [Вербо Е.В., Буцан С.Б., Гилева К.С. *Реконструктивная хирургия лица. Современные методы и принципы.* М., 2022.]. URL: https://www.studentlibrary.ru/book/ISBN9785970469521.html

3. Brown JS, Shaw RJ. Reconstruction of the maxilla and midface: introducing a new classification. *Lancet Oncol.* 2010;11(10):1001-8. DOI: 10.1016/S1470-2045(10)70113-3

4. Ren W, Gao L, Li S, et al. Virtual Planning and 3D printing modeling for mandibular reconstruction with fibula free flap. *Med Oral Patol Oral Cir Bucal.* 2018;23(3):e359-e366. DOI: 10.4317/medoral.22295

5. Ivashkov VYu, Denisenko AS, Kolsanov AV, Verbo EV. An original method of nose reconstruction using an individualized titanium implant and a radial flap: a clinical case. *Issues of Reconstructive and Plastic Surgery.* 2024;27(3):93-99. [Ивашков В.Ю., Денисенко А.С., Колсанов А.В., Вербо Е.В. Оригинальный способ реконструкции наружного носа с применением индивидуального титанового импланта и лучевого лоскута: клинический случай. *Вопросы реконструктивной и пластической хирургии.* 2024;27(3):93-99]. DOI: 10.52581/1814-1471/90/08

6. Ivashkov VYu, Denisenko AS, Kolsanov AV, et al. Mandible reconstruction using the Autoplan software. *Plastic Surgery and Aesthetic Medicine.* 2024;(4-2):58-65. [Ивашков В.Ю., Денисенко А.С., Колсанов А.В., и др. Устранение дефектов нижней челюсти с применением программного комплекса «Автоплан». *Пластическая хирургия и эстетическая медицина.* 2024;(4-2):58-65]. DOI: 10.17116/plast.hirurgia202404258

7. Ivashkov VYu, Semenov SV, Kolsanov AV, et al. Modification of the microsurgical radiation autograft of the "Maple Seed" type. Analysis of a series of clinical observations. *Medline.ru.* 2023;24:1049-1059. (In Russ.). [Ивашков В.Ю., Семенов С.В., Колсанов А.В., и др. Модификация микрохирургического лучевого аутотрансплантата по типу «кленового семени». Анализ серии клинических наблюдений. *Medline.ru.* 2023;24:1049-1059]. https://www.medline.ru/public/art/tom24/art71.html

8. Ringash J. Survivorship and Quality of Life in Head and Neck Cancer. *J Clin Oncol.* 2015;33(29):3322-7. DOI: 10.1200/JCO.2015.61.4115

9. Schardt C, Schmid A, Bodem J, et al. Donor site morbidity and quality of life after microvascular head and neck reconstruction with free fibula and deep-circumflex iliac artery flaps. *J Craniomaxillofac Surg.* 2017;45(2):304-311. DOI: 10.1016/j.jcms.2016.11.014

10. Melville JC, Fernandes RP, Markiewicz MR. Maxillary and Midface Reconstruction: Part I. *Atlas Oral Maxillofac Surg Clin North Am.* 2024;32(2):xiii-xiv. DOI: 10.1016/j.cxom.2023.12.004

11. Callahan N, Pu JJ, Richard Su YX, et al. Benefits and Controversies of Midface and Maxillary Reconstruction. *Atlas Oral Maxillofac Surg Clin North Am.* 2024;32(2):109-116. DOI: 10.1016/j.cxom.2023.12.006

12. Moreno MA, Skoracki RJ, Hanna EY, et al. Microvascular free flap reconstruction versus palatal obturation for maxillectomy defects. *Head Neck.* 2010;32(07):860-868. DOI: 10.1002/hed.21264

13. Bender-Heine A, Wax MK. Reconstruction of the Midface and Palate. *Semin Plast Surg.* 2020;34(2):77-85. DOI: 10.1055/s-0040-1709470

14. Serafin D, Riefkohl R, Thomas I, et al. Vascularized rib-periosteal and osteocutaneous reconstruction of the maxilla and mandible: an assessment. *Plast Reconstr Surg.* 1980;66(5):718-27. DOI: 10.1097/00006534-198011000-00007

15. Baker SR. Closure of large orbital-maxillary defects with free latissimus dorsi myocutaneous flaps. *Head Neck Surg.* 1984;6(4):828-35. DOI: 10.1002/hed.2890060405

16. Swartz WM, Banis JC, Newton ED et al. The osteocutaneous scapular flap for mandibular and maxillary reconstruction. *Plast Reconstr Surg.* 1986;77(4):530-45. DOI: 10.1097/00006534-198604000-00003

17. Fisher J, Jackson IT. Microvascular surgery as an adjunct to craniomaxillofacial reconstruction. *Br J Plast Surg.* 1989;42(2):146-54. DOI: 10.1016/0007-1226(89)90196-3

18. Schusterman MA, Reece GP, Miller MJ. Osseous free flaps for orbit and midface reconstruction. *Am J Surg.* 1993;166(4):341-5. DOI: 10.1016/s0002-9610(05)80328-9

19. Nakayama B, Matsuura H, Hasegawa Y et al. New reconstruction for total maxillectomy defect with a fibula osteocutaneous free flap. *Br J Plast Surg.* 1994;47(4):247-9. DOI: 10.1016/0007-1226(94)90006-x

20. Caldwell A, Cheng A, Patel A, et al. Fibula Reconstruction of the Maxilla and Midface. *Atlas Oral Maxillofac Surg Clin North Am.* 2024;32(2):117-123. DOI: 10.1016/j.cxom.2023.12.007

21. Nedrud S, Bunnell AM, Fernandes R. Deep Circumflex Iliac Artery Free Flap Reconstruction for the Midface and Maxilla. *Atlas Oral Maxillofac Surg Clin North Am.* 2024;32(2):125-133. DOI: 10.1016/j.cxom.2024.01.003

22. Li CQ, Xie S, LiuFu JF, et al. Retrospective study of the deep circumflex iliac artery flap and the vascularized fibula free flap for maxillary defect repair. *Oral Oncol.* 2024;154:106860. DOI: 10.1016/j.oraloncology.2024.106860

23. Ivashkov VYu, Semenov SV, Kolsanov AV, et al. Replacement of combined maxillary defects using additive technologies and composite tissue complex from thoracodorsal artery pool. *Plastic Surgery and Aesthetic Medicine.* 2023;(4):112-119. [Ивашков В.Ю., Семенов С.В., Колсанов А.В., и др. Замещение комбинированных дефектов верхней челюсти с использованием аддитивных технологий и сложносоставного тканевого комплекса из бассейна торакодорзальной артерии. Клинический пример. *Пластическая хирургия и эстетическая медицина.* 2023;(4):112-119]. DOI: 10.17116/plast.hirurgia2023041112

24. Cordeiro PG, Chen CM. A 15-year review of midface reconstruction after total and subtotal maxillectomy: part I. Algorithm and outcomes. *Plast Reconstr Surg.* 2012;129(1):124-136. DOI: 10.1097/PRS.0b013e318221dca4

25. Rogers SN, Lowe D, McNally D, et al. Health-related quality of life after maxillectomy: a comparison between prosthetic obturation and free flap. *J Oral Maxillofac Surg.* 2003;61(2):174-81. DOI: 10.1053/joms.2003.50044

26. Jones EA, Huang AT. Virtual Surgical Planning in Head and Neck Reconstruction. *Otolaryngol Clin North Am.* 2023;56(4):813-822. DOI: 10.1016/j.otc.2023.04.013

27. Barton BM, Pappa AK, Blumberg J, et al. Reconstruction of oral cavity defects using myogenous-only scapular tip free-flaps. *Laryngoscope Investig Otolaryngol.* 2022;7(4):955-962. DOI: 10.1002/lio2.848

28. Lee KC, Neal TW, Tung R, et al. History of Maxillary Reconstruction. *Atlas Oral Maxillofac Surg Clin North Am.* 2024;32(2):65-71. DOI: 10.1016/j.cxom.2023.12.001

29. Zhang WB, Yu Y, Wang Y, et al. Surgical reconstruction of maxillary defects using a computer-assisted techniques. 2017;49(1):1-5. [Article in Chinese]. PMID: 28202996/