Oral cancer reconstructive surgery using the free radial forearm flap (review)

H. Chen[1, 2], A.M. Mudunov[1, 2], R.I. Azizian[2], I.N. Pustynskiy[2, 3], D.K. Stelmah[2]

[1]I.M. Sechenov First Moscow State Medical University, Ministry of Health of Russia; Bld. 4, 2 Bolshaya Pirogovskaya St., Moscow 119991, Russia;

[2]N.N. Blokhin National Medical Research Center of Oncology, Ministry of Health of Russia; 24 Kashirskoe Shosse, Moscow 115478, Russia;

[3]N.I. Pirogov Russian National Research Medical University, Ministry of Health of Russia; 1 Ostrovityanova St., Moscow 117997, Russia

This review covers the issues related to the application of radial free forearm flaps for the reconstruction of defects after surgeries for oral squamous cell carcinoma. The advantages of this method include optimal match of the flap to the tissues of the oral cavity, good adaptation to defect edges, and possibility to replace defects of almost any size and locations. Flap survival rate reaches 92.0–98.4 %. The method demonstrated good functional and aesthetic results when used for the repair of extensive defects of the tongue, oral floor, cheeks, as well as total defects of the lips, hard and soft palates. The main disadvantages of the method include aesthetic defects of the donor site and possible forearm dysfunction, but most patients are quite comfortable with these inconveniences. The death rate is 0.09 %; the incidence of complications is 15–24 %. The main cause of graft failure in this case is venous thrombosis. Advanced age is not currently considered as a contraindication for this method. Further studies evaluating free radial flaps are highly relevant, particularly those comparing this method with other ones and determining strict indications for it (such as size and location of the defect, tumor characteristics, and previous treatment).

Key words: *free radial flap, oral squamous cell carcinoma, reconstructive surgery, advantages, disadvantages, contraindications, complications*

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Реконструктивные операции с использованием свободного лучевого лоскута при раке полости рта (обзор литературы)

Х. Чень[1, 2], А.М. Мудунов[1, 2], Р.И. Азизян[2], И.Н. Пустынский[2, 3], Д.К. Стельмах[2]

[1]ФГАОУ ВО Первый Московский государственный медицинский университет им. И.М. Сеченова Минздрава России; Россия, 119991 Москва, ул. Большая Пироговская, 2, стр. 4;

[2]ФГБУ «Национальный медицинский исследовательский центр онкологии им. Н.Н. Блохина» Минздрава России; Россия, 115478 Москва, Каширское шоссе, 24;

[3]ФГАОУ ВО «Российский национальный исследовательский медицинский университет им. Н.И. Пирогова» Минздрава России; Россия, 117997 Москва, ул. Островитянова, 1

Контакты: *Али Мурадович Мудунов ali.mudunov@inbox.ru*

В настоящем обзоре рассмотрены вопросы применения лучевого свободного лоскута предплечья для замещения дефектов после хирургического удаления плоскоклеточного рака полости рта. Преимущества метода заключаются в оптимальном соответствии лоскута тканям полости рта, хорошей адаптации к краям дефектов, возможности замещать дефекты практически любых размеров и локализации. Полное приживление лучевого лоскута, по разным данным, наблюдается в 92,0–98,4 % случаев. Функциональные и эстетические результаты оценены как хорошие при замещении обширных дефектов языка и дна полости рта, щеки, тотальных дефектов губ, твердого и мягкого неба. Основные недостатки метода состоят в неэстетичном виде донорской зоны и возможном развитии нарушений функций предплечья, однако большинство пациентов достаточно спокойно переносят эти неудобства. Летальность составляет 0,09 %, общая частота осложнений – 15–24 %. Основной причиной неудач при использовании данного лоскута является тромбоз вен. Пожилой возраст пациента в настоящее время не считается противопоказанием к использованию метода. Актуальным представляется дальнейшее изучение особенностей свободного лучевого лоскута в сравнении с другими видами трансплантатов и определение четких показаний к его использованию (той или иной распространенности и локализации дефекта, характеристик опухоли и ранее проведенного лечения).

Ключевые слова: *свободный лучевой лоскут, плоскоклеточный рак полости рта, реконструктивные операции, преимущества, недостатки, противопоказания, осложнения*

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Background

Oral cancer is the most common type of squamous cell carcinoma of the head and neck and at the same time one of the most aggressive malignancies [1–3]. Russia is currently experiencing an increase in the incidence of oral cancers: there was a 35% increase in the number of newly diagnosed cases over the past 10 years (from 5.08 cases per 100,000 in 2009 to 6.63 cases per 100,000 in 2018). Mean age of patients was 61 years; men are 2.2 times more likely to develop this disease than women [4]. More than 60% of patients have locally advanced and advanced stage III and IV tumors characterized by poor prognosis. Oral cancer is one of the most common malignancies causing death, including that among people of working age. In Russia, oral cancer is the third most common malignant tumor (after lung cancer and gastric cancer) causing death in men aged 40–59 years [5].

Surgical tumor removal is the main method of treating patients with locally advanced oral cancer and is used as a part of combination or comprehensive therapy [1, 6, 7]. Extended and extended-combination surgeries are used to remove malignant oral tumors. However, the defects after such surgeries are associated with severe impairments of vital functions, including breathing, eating, speech, as well as cosmetic defects, which requires effective methods of reconstruction to achieve optimal aesthetic and functional results. The development of reconstructive surgeries that can improve patients' quality of life after the removal of oral tumors is one of the most urgent problems in oncology [1, 8, 9].

Free revascularized flaps have become increasingly popular to repair extensive and complex oral defects. Defect repair with free flaps is one of the most popular and reliable surgical methods, without which current reconstructive surgery of the head and neck is practically impossible [10–12].

After summarizing the experience of 200 European departments of maxillofacial surgery with the assistance of the European Association for Cranio-Maxillo-Facial Surgery, Kansy et al. [13] concluded that microvascular surgery is a common and safe method of reconstructive surgery after removing head and neck tumors. Husso et al. investigated the development of microsurgical reconstruction techniques for the head and neck by analyzing the experience of Helsinki University Hospital, where 594 operations were performed in 541 patients between 1995 and 2012. They found an increase in the mean patient age (from 53 to 56 years), constant predominance of men (60%), greater variety of flap variants used, and their stable survival rate (97%). The analysis of clinical data demonstrated that the choice of reconstructive methods has become more individual and patient-specific, the incidence of complications has reduced, despite some increase in the mean age of patients [11].

Advanced age is not currently considered as a contraindication for this method of reconstructive surgery. Otsuki et al. have analyzed the results of using free revascularized grafts in 13 patients aged 80 to 91 years (mean age 82.6 ± 3.4 years). The duration of subsequent follow-up varied between 4 and 41 months (median 23.3 months). All patients were alive during the first year after surgery. Two patients developed flap necrosis. The authors concluded that reconstructive surgery with free flaps is an effective and fairly safe method for elderly patients [14].

There are 3 most common types of free flaps used in reconstruction of head and neck defects: radial flap, anterolateral (lateral) thigh flap, and fibular flap [15].

The free radial flap is a thin, elastic, and almost hairless skin fascial flap, which can be well adapted in the recipient area during the repair of irregular-shaped defects, which makes this flap perfect for large defects in the oral cavity and some other areas in the head and neck.

The method of tissue reconstruction with a free radial flap was developed by G. F. Yang in 1981 and was implemented into clinical practice by R. Song, who used it to repair neck defects [16].

Currently, free radial flaps are widely used in various types of reconstructive surgery. Pabst et al. [17] calculated that a total of 1,056 papers devoted to free radial flaps had been published between 1982 and 2017. New surgical approaches and techniques allow quick and safe harvesting of a free radial flap. Reconstructive surgery with this flap was proved to be a safe, robust, and universal method of for various defects in the head and neck area [18–21].

Complications associated with free radial flaps

C. Zhang et al. have analyzed the results of 4,640 reconstructive surgeries performed over 34 years in the Ninth People's Hospital (Shanghai, China) with free revascularized flaps, including radial flaps (56%), fibular flaps (13%), anterolateral thigh flaps (10%), iliac crest flaps (10%), and other flaps (11%). Four patients (0.09%) died in the postoperative period. The most common cause of complications was venous thrombosis. The findings of this study suggest higher incidence of serious postoperative complications in patients who had previously undergone radiotherapy compared to those who had had no radiotherapy (22.0% and 6.9%, respectively). The authors believe that free flaps are safe in general, but this technique requires certain clinical experience in order to choose optimal material for tissue repair [22].

The experience of 259 surgeries with free revascularized flaps used to replace the defects after the removal of malignant head and neck tumors is described in the work of Llorente et al. All patients in this study had complex defects with 43% of them having recurrent malignancies. Radial flaps were used in 41% of participants, whereas 35% of patients have their defects repaired using anterolateral thigh flaps. Complete flap survival was observed in 92% of patients; various complications were registered in 20% of cases [23].

Tornero et al. analyzed the outcomes of 36 surgeries with simultaneous reconstruction of oropharyngeal defects after the removal of various tumors (oropharyngeal cancer in 58% of cases). In the postoperative period, partial suture

disruption was observed in 5 patients (13.9%); 1 patient developed pharyngostoma; none of the patients died. This study has also shown that previous radiotherapy significantly increases the incidence of complications [24].

In order to determine perioperative risk factors for complications associated with radial flaps used to repair the maxillofacial area, Wang et al. have analyzed the results of treatment of 169 patients, 26 of whom (15.4%) developed various complications. The risk depended on such factors as preoperative radiotherapy, postoperative levels of hemoglobin and albumin, pain severity (assessed by the visual analogue scale), and the volume of crystalloids transfused within 24 hours. In general, the authors considered this technique as highly robust [25].

Advantages of the radial flap

Reconstructive surgeries with free radial flaps ensured good short-term (aesthetic and functional) and long-term results in repairing the defects after treatment of locally advanced cancer of the tongue, cheek mucosa, lips, and hard and soft palates. It has been shown that the repair of oral defects with radial flaps after hemiglossectomy have some advantages over other reconstructive techniques in terms of restoring speech and swallowing (there was a progressive improvement 1 and 6 months postoperatively) [26]. Akashi et al. analyzed long-term treatment outcomes in 23 patients who had undergone hemiglossectomy for tongue cancer followed by oral defect reconstruction with a free radial flap. The duration of follow-up period varied between 60 and 122 months (mean 85.4 months). Speech, swallowing, and flap sensitivity were evaluated in the postoperative period. All patients demonstrated gradual improvement postoperatively with the most significant improvement registered 1–5 years after surgery. During follow-up, morphological changes in the flap were insignificant in all cases, and the postoperative status of patients gradually improved [27].

Li et al. performed long-term assessment of patients' quality of life after the removal of locally advanced head and neck tumors and defect reconstruction with a free radial flap. The authors used specially designed questionnaires to assess the quality of life that had to be filled in by patients and sent by mail. Out of 178 participants, 87 (48.9 %) informed that they were alive and relatively healthy. Fifty-six patients (64.4%) sent completed questionnaires. The duration of follow-up varied between 3 and 13 years (mean 7.9 years). The most highly rated parameters included pain intensity, emotional state, anxiety level, and the condition of the donor area. Lower rates were given to speech, taste perception, and salivation. Considering the fact that those patients had advanced disease, long-term treatment outcomes were generally good [28].

Experience in reconstructing through-and-through cheek defects using a free radial flap after tumor excision was described by Ma et al. All patients demonstrated complete survival of the flaps. The follow-up period lasted 6–36 months, during which the authors observed satisfactory restoration of the cheek shape, as well as functions of the oral cavity. One patient died due to lung metastases. The authors characterize this method for repairing through-and-through cheek defects after the removal of locally advanced oral tumors as highly effective and robust [29].

Free radial flaps allow effective repair of large defects of the hard and soft palates. Song et al. have described successful use of a radial flap in 6 patients with extensive combined defects of the soft and hard palates. All patients demonstrated complete flap survival and could eat without nasal regurgitation. Subsequent follow-up lasted for 3–24 months and showed that all patients were satisfied with their quality of life [30]. Successful use of a free radial flap in the reconstruction of extensive palate defects has also been demonstrated by Ashok et al., who emphasized the importance of protecting the pedicle of the flap, which is constantly exposed to nasal secretions and turbulent air flow. The authors have developed an original reconstructive technique aimed to 'wrap' the pedicle and nose side of the flap with tissues for protection [31].

Successful use of free radial flaps for the reconstruction of total lip defects have been reported by Rahman et al. All five study participants had complete flap survival, as well as restoration of speech and oral continence [32].

Thus, many researchers have demonstrated good functional results of reconstructive surgeries with free radial flaps used to repair extensive defects of the oral cavity. W. Su and D. Zhao have analyzed the outcomes of reconstructive surgeries in 70 patients for cancer of the tongue (n = 43), cheek (n = 12), oropharynx (n = 6), nose (n = 4) and lips (n = 5). The area of defects varied between 5 × 4 cm and 14 × 8 cm. The authors concluded that the use of free radial flap is an effective method of functional reconstruction of such defects. Only one patient developed radial flap necrosis caused by venous thrombosis, while the rest of the patients (98.4%) had complete flap survival. Three patients died 12–36 months postoperatively: one due to disease progression and two due to concomitant cardiovascular diseases [33].

Disadvantages of radial flaps

Along with undoubted advantages of free radial flaps, they have a number of disadvantages. One of them is the appearance of the donor site, which is visible when a patient is wearing clothing without sleeves or with short sleeves. Hand complications include edema, lower strength and mobility, loss of sensitivity due to damage to the superficial branches of the radial nerve, and cold intolerance. Minkara et al. have developed a questionnaire for assessing impairments of the forearm and hand in the long-term period after radial flap harvesting. Using this questionnaire, the authors identified long-term impairments of the functional activity of the arm, where the donor area was located [34].

Researchers have developed a number of surgical techniques to almost completely eliminate the problems

associated with closing the wound in the donor area. Repair of a skin defect in the donor area on the forearm with a full-layer skin flap taken from the neck skin gives good functional and aesthetic results in most cases. Hanna et al. found that the incidence of postoperative complications after surgeries with free radial flaps was not higher than that with other reconstructive methods; none of the patients operated required additional interventions to close the wound in the area of full-layer skin flap harvesting; all wounds healed by primary intention shortly after surgery [35].

It is advisable to use local tissues to close the forearm wound if the size of the defect and its characteristics allow it. The use of local tissues to close the forearm defect prevents the formation of a second donor area and eliminate the shortcomings associated with split-thickness skin flaps. At the same time, although the decrease in the strength of the forearm muscles and the freedom of wrist movements can be objectively assessed after flap harvesting, these data do not fully reflect the scale of limitations that the patient subjectively perceives in everyday life [36].

After analyzing the results of 171 operations with free radial revascularized flaps, Yun et al. concluded that it is possible to achieve acceptable aesthetic and functional results in the donor area if the surgeon uses an optimal technique for flap harvesting and wound closure. The results were better in non-obese patients without diabetes and severe cardiovascular diseases [37]. The findings of this study suggest that possible concern about the condition of the donor area should not be a reason for refusing from this technique [38].

The advantages of operations with free radial flaps outweigh their disadvantages and make this technique very popular in head and neck reconstructive surgery. According to the majority of plastic surgeons, patients find themselves in a very difficult situation due to advanced disease, so the inconveniences associated with donor site are usually well tolerated by patients and do not become a factor that prevents the use of a free radial flap [39].

Comparison of the radial flap with other grafts

The implementation of free revascularized autologous grafts into clinical practice have created the problem of choosing an appropriate donor material. Lee et al. compared the effectiveness of free radial flaps and anterolateral thigh flaps for the reconstruction of oral defects. They have found good survival of both flaps with complete flap survival observed in 95.6% of patients with free radial flaps and 100% of patients with anterolateral thigh flaps. As an argument to use the anterolateral thigh flap, the authors describe discomfort in the donor site reported by 48% of patients after radial flap surgery, which was not observed with anterolateral tight flaps. Moreover, in 22 out of 23 cases, free skin flaps were required to close the wound on the forearm. During long-term follow-up, functional disorders in the donor site (forearm) were registered in 17% of patients [40].

Oranges et al. compared various flaps in their study. They used free radial flaps in 29 patients and anterolateral thigh flaps in 10 patients. Complete flap survival was observed in 97% of patients with radial flaps and 90% of patients with anterolateral thigh flaps. Donor site complications were registered in 6% and 7% of patients with radial and anterolateral thigh flaps respectively. Systemic complications were registered in 24% and 20% of patients with radial and anterolateral thigh flaps respectively. Thus, the analysis demonstrated no significant differences between the results of surgeries with different types of flaps. Both types of flaps demonstrated the same robustness in the reconstruction of head and neck soft tissues and the same incidence of complications [41].

Zhang et al. described the advantages of a free radial flap over anterolateral thigh flap in restoring oral functions, such as chewing, speech, and swallowing, as well as in the reconstruction of the tongue after hemiglossectomy [42].

After analyzing literature data and own clinical data (included 60 cases), Benanti et al. have developed an algorithm for choosing optimal graft material for repairing oral defects. The authors found that the radial flaps and anterolateral thigh flaps are primarily used in the reconstruction of soft tissue defects of the oral cavity. However, due to the lack of standardized indications for a particular type of plastic surgery, each surgeon chooses a flap largely according to his own preferences and experience [43].

Yang et al. performed comparative analysis of pedicle flaps with the inclusion of sternocleidomastoid muscle and free revascularized flaps for the reconstruction of oral defects. Comprehensive analysis of treatment outcomes demonstrated that the choice of a particular flap depends on a number of factors, including location and spread of the tumor, presence of regional metastases, and age and general condition of the patient. The sternocleidomastoid flap is recommended for elderly patients with concomitant diseases and T1–2 tumors [44].

Spiegel et al. performed a retrospective analysis of the results of surgeries with supraclavicular and radial flaps used to repair oral defects in patients with locally advanced squamous cell carcinoma of the oral cavity and oropharynx ($n = 24$). The mean duration of follow-up was 22.2 ± 9.5 months. The authors concluded that according to various criteria, the supraclavicular flap can be used as an alternative to radial flap if possible, but free radial flaps should remain the gold standard for reconstructing head and neck defects [45]. Zhang et al. compared the results of reconstruction of tongue defects using free radial ($n = 15$) and supraclavicular ($n = 12$) flaps. All patients demonstrated good flap survival and no complications. No differences were also observed in speech and swallowing; however, the condition of the donor site was better among patients with supraclavicular flaps [46]. C. Welz performed a retrospective study that included 83 patients with oral and oropharyngeal cancer, who had undergone reconstructive surgery using radial or supraclavicular flaps.

Fifty patients (60.2%) had grade III or IV cancer. There were no significant differences in the frequency of postoperative complications and in the swallowing function after surgery between the two groups studied. Supraclavicular flap was also associated with lower costs, complexity, and duration of surgery [47]. Nevertheless, it should be mentioned that the supraclavicular flap is harvested in the area of potential regional metastasis, so it may become involved in necessary therapeutic interventions, such as surgical excision of the neck tissue and radiation therapy; therefore, not all patients can use this type of plastic surgery.

Kropotov et al., have analyzed the results of reconstruction of oral and oropharyngeal defects using chin flaps and free revascularized radial flaps. The authors believe that both flaps can be successfully used to repair defects in the mucous membrane and soft tissues of the oral cavity in patients with primary and recurrent cancer, while the chin flap is characterized by better intra- and postoperative time parameters and comparable parameters of locoregional control [19].

Li et al. performed a survey among patients who had undergone reconstruction of extensive and complex oral defects with free radial flaps and pectoralis major muscle flaps. Functional results were better after free radial flap surgeries [48].

Zhu et al. have found that the restoration of sensitivity is more active in case of using flaps with preserved axial blood supply than in case of using free radial flap; however, the indications for a particular type of plastic surgery differ significantly, which requires further research. For limited tongue defects, in particular those after hemiglossectomy, the authors recommend first of all flaps with an axial vascular pattern as a simpler and less effort-consuming material [49]. The reconstruction of more complex and extensive defects requires free revascularized autologous grafts that ensure good aesthetic and functional results [27, 28, 33, 50].

Conclusion

Due to a number of advantages and specific characteristics, the free radial flap is one of the most popular free grafts used for the reconstruction of defects after oral tumor removal. The advantages of this method include optimal compliance of the flap with oral tissues, good adaptation to the edges of defects, and the ability to repair oral defects of almost any size and location. This technique has been demonstrated to be highly robust: complete flap survival was observed in 92.0–98.4% of cases. The main cause of failures was venous thrombosis. The method is characterized by low postoperative mortality (0.09% according to some reports). The overall complication rate was 15–24 %. Advanced age is not currently considered as a contraindication for such surgeries. This method ensured good functional and aesthetic results in case of extensive defects of the tongue, oral floor, cheeks, total lip defects, and hard and soft palates. After surgery, there was a gradual improvement in the functional activity of oral organs.

The main disadvantages of this method include the appearance of the donor site and disorders of the forearm, but they can be largely eliminated by using special techniques. The majority of authors emphasize that patients usually take these inconveniences easy; therefore, they shouldn't restrict the use of radial flaps considering significant tumor spread. Due to the lack of standardized indications for a particular type of plastic surgery, the choice of the flap is currently made by a surgeon and depends on his preferences and experience. It is still important to continue the studies analyzing free radial flaps in comparison with other types of flaps and to determine clear indications for their use, depending on the size of the defect, its location in a particular part of the oral cavity, characteristics of the tumor, and previous treatment.

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Authors' contributions
H. Chen: reviewing of publications on the article's theme, article writing;
A.M. Mudunov: leadership of the research team, reviewing of publications on the article's theme, scientific editing of the article;
R.I. Azizian: reviewing of publications on the article's theme, scientific editing of the article;
I.N. Pustynskiy: reviewing of publications on the article's theme, article writing;
D.K. Stelmah: reviewing of publications on the article's theme.

Вклад авторов
Х. Чень: обзор публикаций по теме статьи, написание текста статьи;
А.М. Мудунов: руководство исследовательской группой, обзор литературы по теме статьи, научное редактирование статьи;
Р.И. Азизян: обзор литературы по теме статьи, научное редактирование статьи;
И.Н. Пустынский: обзор литературы по теме статьи, написание текста статьи;
Д.К. Стельмах: обзор литературы по теме статьи.

ORCID авторов / ORCID of authors
Х. Чень / H. Chen: https://orcid.org/0000-0001-7690-731X
А.М. Мудунов / A.M. Mudunov: https://orcid.org/0000-0003-1255-5700
Р.И. Азизян / R.I. Azizian: https://orcid.org/0000-0002-4046-1894
И.Н. Пустынский / I.N. Pustynskiy: https://orcid.org/0000-0002-0903-4536
Д.К. Стельмах / D.K. Stelmah: https://orcid.org/0000-0002-6178-2777

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