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RESTORATION OF ORAL CAVITY FUNCTION BY COMBINATION OF RECONSTRUCTION TECHNIQUES WITH COMPUTER-AIDED DESIGN/COMPUTER-AIDED MANUFACTURE PLANNING METHODS

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ABSTRACT

Introduction. Locally advanced cancer of oral mucosa and oropharynx extending to the mandible is an indication for its segmental resection. After mandible resection, especially after combined and extended radical resection of the floor of the mouth including the mandible, restoration of form and function is of primary importance for patients' rehabilitation.

Case presentation. A 64-year-old man was diagnosed with cancer of the anterior section of the mouth floor, with metastases to neck lymph nodes, stage IV grade II ($T_4N_1M_0$). Computed tomography scan identified lytic destruction of the alveolar process in the range of 32-33 teeth. The pathohistological examination diagnosed a G2 squamous cell carcinoma. A lower temporary tracheostomy was performed, with neck dissection on both sides, resection of the floor of the oral cavity with partial tongue resection, segmental mandible resection, reconstruction of the floor of the floor of the floor of the oral cavity and tongue with the radial forearm free flap. A resection template was used for segmental

Résumé

Restauration de la fonction de la cavité orale par combinaison de techniques de reconstruction avec des méthodes de conception assistée par ordinateur/ de planification de fabrication assistée par ordinateur

Introduction. Le cancer localement avancé de la muqueuse buccale et de l'oropharynx s'étendant à la mandibule est une indication de sa résection segmentaire. Après résection mandibulaire, en particulier après résection radicale combinée et étendue du plancher buccal incluant la mandibule, la restauration de la forme et de la fonction est primordiale pour la rééducation des patients.

Présentation du cas. Un homme de 64 ans a reçu un diagnostic de cancer de la partie antérieure du plancher buccal, avec métastases aux ganglions lymphatiques du cou, stade IV grade II ($T_4N_1M_0$). La tomodensitométrie a identifié une destruction lytique du processus alvéolaire dans la gamme de 32 à 33 dents. L'examen anatomopathologique a diagnostiqué un carcinome épidermoïde G2. Une trachéotomie temporaire

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National Pirogov Memorial Medical University, Vinnytsya, Ukraine Address: Pirogova str., no. 56, Vinnytsya, 21018, Ukraine Email: dr_anna9@ukr.net; Phone +38 0677903790 resection of the mandible. Long-term postoperative regional analgesia was used. During surgical treatment, it was necessary to choose the type of reconstruction to restore the shape, volume and functionality of the organ.

Conclusions. This case demonstrates good functional (restoration and preservation of chewing and swallowing) and aesthetic results when using free bone and fasciocutaneous free flaps for primary mandibular reconstruction. The use of computer-aided design/ computer-aided manufacture technology improves the quality of reconstruction and minimizes the likelihood of complications.

Keywords: radial forearm free flap, cancer, swallowing, chewing, anesthesia.

List of abbreviations

CAD – computer-aided design CAM – computer-aided manufacture

INTRODUCTION

Locally advanced cancer of the oral mucosa and oropharynx extending to the mandible is an indication for its segmental resection¹. Disruption of the continuity of the mandible leads to difficulties in chewing, swallowing and speech². Malocclusion and problems with proprioception occur, as well^{3, 4}. These functions can be restored with bone and vascularized flaps providing a stable structure to which the muscles are attached. Accordingly, restoring the continuity of the mandible facilitates chewing, swallowing, speaking and breathing, by preserving space in the oral cavity and allowing the tongue to move. In addition, the mandible forms the contour of the lower third of the face, and without restoration it leads to aesthetic disorders that negatively affect the quality of life⁵.

The indications for mandible reconstruction are tumours of the oral cavity and oropharynx⁶. After mandible resection, especially after combined and extended radical resection of the floor of the mouth, including the mandible, the restoration of its form and function is of primary importance for patients rehabilitation^{7,8}. Therefore, the goal of surgery is not only radical tumour removal but also restoration of the continuity and anatomical shape of the mandible.

The progresses in mandibular reconstruction, where autogenous bone grafting is the mainstay, have

inférieure a été réalisée, avec curage du cou des deux côtés, résection du plancher de la cavité buccale avec résection partielle de la langue, résection segmentaire de la mandibule, reconstruction de la mandibule avec une crête iliaque non vascularisée, reconstruction du plancher de la cavité buccale cavité et langue avec le lambeau libre radial de l'avant-bras. Un gabarit de résection a été utilisé pour la résection segmentaire de la mandibule. Une analgésie régionale postopératoire à long terme a été utilisée. Lors du traitement chirurgical, il a fallu choisir le type de reconstruction pour restaurer la forme, le volume et la fonctionnalité de l'organe.

Conclusions. Ce cas démontre de bons résultats fonctionnels (restauration et préservation de la mastication et de la déglutition) et esthétiques lors de l'utilisation d'os libre et de lambeaux libres fasciocutanés pour la reconstruction mandibulaire primaire. L'utilisation de la technologie de conception/fabrication assistée par ordinateur améliore la qualité de la reconstruction et minimise le risque de complications.

Mots-clés: lambeau libre d'avant-bras radial, cancer, déglutition, mastication, anesthésie.

significantly improved the functional and aesthetic outcomes⁹. There are several techniques, including non-vascularized and vascularized bone autografts. The sites for transplantation of non-vascularized autogenous bone can be divided into local and distant sites. If the defect is small, local or intraoral donor sites are sufficient. When moderate or significant amount of bone is required, usually distant or extraoral sites are used¹⁰. Common donor sites for free bone tissue are the iliac crest, fibula, scapula and radius^{11,12}. Free revascularized myocutaneous and fasciocutaneous flaps, regional flaps with vascular pedicle, osteocutaneous flaps and their combination with reconstructive plates, synthetic implants, tissue engineering technologies are also used for reconstruction of postoperative defects^{13,14}. All these techniques are used in various combinations to achieve an optimal result of surgical treatment.

The use of reconstructive plates is possible for plastic elimination of segmental defects of the mandible in the absence of significant soft tissue defect, as well as in patients with complex concomitant pathology which does not allow for full reconstruction. Miles et al. note that the main complications after the use of reconstructive plates without tight closure are their eruption through the mucous membrane into the oral cavity or through the skin outside¹⁵.

In segmental resections of the mandible combined with defects of the mucous membrane or soft tissues, bone grafts and reconstructive plates in combination with fasciocutaneous and myocutaneous flaps are used. Myocutaneous flap of the pectoralis major muscle, free myocutaneous flap of the broadest muscle of the back or rectus abdominis, anterolateral flap of the thigh, radial forearm free flap are used¹⁶. The myocutaneous flap not only covers the soft tissue defect, but also prevents the eruption of reconstructive plate¹⁷.

CASE PRESENTATION

A 64-year-old male patient, diagnosed with cancer of the anterior section of the mouth floor, with metastases to the neck lymph nodes stage IV grade II ($T_4N_1M_0$), who did not receive previous treatment, underwent combined extended surgery in the Department of Head and Neck Tumours of Podilskyi Oncology Center, Vinnytsia, Ukraine (Figure 1). The surgical intervention consisted in lower temporary tracheostomy, neck dissection on both sides, resection of the floor of the oral cavity with partial tongue resection, segmental mandible resection, reconstruction of the mandible with non-vascularized iliac crest, reconstruction of the oral cavity floor and tongue with radial forearm free flap. The resection template was used for segmental resection of the mandible (Figure 2).

The tumour was removed in a single block (Figure 3).

The iliac crest was also prepared using a resection template (Figure 4).

Pre-prepared and curved standard titanium plate and mini-plates using 3D printed models of the patient's mandible were used (Figure 5).

Fixation of the bone graft was performed using 2.0 mm titanium plates (Figure 6).

A radial forearm free flap was harvested from the non-dominant arm. The radial artery and the cephalic vein were anastomosed to the facial artery and vein, respectively (Figure 7).

The patient received intraoperative and postoperative analgesia by prolonged conductive postoperative anesthesia with ultracaine 4% solution 1 ml in each catheter, in combination with non-steroidal anti-inflammatory drugs (Figure 8).

The skin part of the radial forearm free flap was used to reconstruct the defect of the anterior part of the mouth floor and tongue (Figure 9).

The area of the forearm with skin defect after harvesting was restored with free dermal flap (Figure 10).

Postoperatively, the patient had an intact occlusion in the lateral group of teeth and a correct facial contour (Figure 11).



Figure 1. Cancer of the anterior section of the mouth floor.



Figure 2. A – resection template with marking of resection axis guides and holes for screws fixing titanium plates; B – resection template fixed on the mandible.

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Figure 3. Fragment of the mandible with tumour.



Figure 4. Bicortical bone graft from the iliac crest for reconstruction of the chin area of the mandible with applied resection template.

Nutrition in the postoperative period was enter-

al – tube feeding with «Peptamen» and intravenous amino acid complex of L-arginine and glutamic acid.



Figure 5. Printed mandibular models and iliac crest fragment with resection templates. Pre-curved and fitted titanium plate.

In order to assess the functional status, the chewing efficiency and ultrasound diagnostics of the swallowing act in the pre- and postoperative periods were performed.

Chewing efficiency was determined using two-color chewing gum Orophys Hue-chek gum

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Figure 6. Fixed bicortical bone graft from the iliac crest in the area of mandibular defect.



Figure 7. Microvascular anastomosis between the radial artery and facial artery (A), between the cephalic vein and facial vein (B).



Figure 8. Long-term postoperative regional pain relief on the right (A) – anesthesia of the mandibular nerve (a), catheter in the projection of the glossopharyngeal nerve (b) and on the left (B) – catheter near the foramen ovale.

(Switzerland). The chewing test is based on mixing gums of two colors for 20 chewing movements. The software and calculations included the Viewgum package and Exel (Figure 12).

Using k-means clustering method, the chewing efficiency was evaluated for each bolus by evaluating the mixed and unmixed areas. Before surgery, the chewing efficiency was 0.82, being indicative of good mixing of the bolus. After surgical treatment it was 0.61, suggesting moderate mixing of the bolus.

The act of swallowing was studied by ultrasound and the following indicators were determined: chin-hyoid distance, suprahyoid muscle group on the right and left. Indicators were recorded at rest and



Figure 9. The area of soft tissue reconstruction of the floor of the mouth and tongue with radial forearm free flap after 4 weeks.

during swallowing before surgical treatment and after reconstruction (Table 1).

Ultrasound examination revealed a decreased amplitude of muscle contraction. After surgery, a decrease in all indicators was observed. The ultrasound examination before surgery revealed decreased amplitude of muscle contraction on the affected side. Thus, the difference in muscle contractions of the chin-hyoid distance was smaller by 2.8 mm and the amplitude of contraction of the suprahyoid muscle group on the affected side was < 1 mm, while on unaffected side it was > 1 mm. The obtained values of chewing efficiency and the act of swallowing in the postoperative period indicate the restoration of the function of oral cavity organs.

Pain sensations during swallowing were determined using the Visual Analog Scale (VAS) on the 1^{st} day – 6 points, the 3^{rd} day – 4 points, the 5^{th} day – 3 points, the 7^{th} – 2 points, and the 10^{th} day – 0 points.



Figure 10. Donor forearm area covered with a dermal flap. A – appearance of the wound after 5 days, B – appearance of the wound after 6 months.



Figure 11. Patient's appearance 4 weeks after surgical treatment.

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Figure 12. Mixed rubbers with selected segments of study. A – before operative treatment; B – after surgery.

Table 1. The study of the act of swallowing.				
Study period	Action	Research indicators		
		chin-hyoid distance (mm)	suprahyoid muscle group healthy side (mm)	suprahyoid muscle group affected side (mm)
Before surgery	rest	38.7	7.6	6.9
	swallow	27.9	9.8	8.6
After surgery	rest	37.5	6.9	5.3
	swallow	29.5	8.8	6.5

Table 1. The study of the act of swallowing.

Positive dynamics in pain index were observed, being indicative of high-quality long-term postoperative regional analgesia.

The levels of total protein, albumin, and absolute number of lymphocytes before the operation were 60 g/L, 31 g/L and 1500/µl, respectively, while after the treatment the corresponding values were 76 g/L, 37 g/L and 1810/µl, respectively. Before surgery the values of urea, glucose, ketone bodies were 6.3 mmol/L, 4.3 mmol/L, 1.2 mmol/L, respectively, while after treatment they were 5.4 mmol/L, 4.5 mmol/L and 0.9 mmol/L, respectively. The results demonstrate the positive effect of supportive therapy on protein and carbohydrate metabolism.

During inpatient treatment, the influence of surgical treatment and analgesic therapy on the quality of life was evaluated by the method of Long-term postoperative regional anesthesia, while comparative therapy results were studied using European Organization for Research and Treatment of Cancer – quality of life questionnaire – head and neck (EORTC-QLQ-H&N35) questionnaire on the 3rd, 7th and 10th postoperative days. A positive dynamics was observed on the 3rd day – 61 points, on the 7th day – 52 and on the 10th day – 39 points.

DISCUSSION

Currently, autogenous bone grafting is the gold standard for bone reconstruction of the mandible and among other available options is a reliable and predictable method of restoring the shape and function of mandible missing segment. Non-vascularized bone graft, such as the iliac crest, is an option for reconstruction of small mandibular defects (<6 cm). The iliac crest contains a large fragment of curved corticobuccal bone 6 to 16 cm in length. It has natural curvature that complements the curvature of the lateral and sometimes anterior part of the mandible necessary for defect reconstruction. The advantages of this bone flap include the height of the bone being greater than the fibula flap and a better cosmetic appearance of donor site. In the case of the defect extending along the midline, an osteotomy can be performed, to recreate the contour of the anterior mandible.

Modern planning methods, including computer-aided design (CAD)/ computer-aided manufacturing (CAM) offer new approaches in reconstructive surgery, optimization of aesthetic results and functional rehabilitation of the patient. Preoperative planning, modeling, model fabrication and guided resection using resection templates have greatly facilitated complex three-dimensional reconstruction, especially of the mandible¹⁸.

Vascularized free skin flap transfer has shown excellent long-term aesthetic and functional results¹⁹. Fasciocutaneous flaps such as radial forearm free flap have been successfully used in the reconstruction of postoperative defects of the oral cavity. Virtual planning and guided reconstruction of the mandible after combined and extended surgery are important in reconstructive surgery for clean resection margins, bone fitting and consolidation of its fragments, reduction of operative time as well²⁰. Integration of CAD/CAM technology in the preoperative and intraoperative process reduces the time of surgery and the patient's hospital stay, as well as improves consolidation, symmetry and bone morphology.

Therefore, the use of non-vascularized bone and reconstructive plate in combination with fasciocutaneous flaps remains the method of choice in certain clinical situations.

CONCLUSIONS

This case demonstrates good functional (restoration and preservation of chewing and swallowing) and aesthetic results when using free bone and fasciocutaneous free flaps for primary mandibular reconstruction. The use of CAD/CAM technology improves the quality of reconstruction and minimizes the likelihood of complications. The restoration of the form and function of the oral cavity has positive effects on the patient's quality of life.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. The patient gave his consent for his images and other clinical information to be reported in the journal. The patient understands that name and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

Author Contributions

Z.V.B. was responsible for the clinical diagnosis, treatment decisions, performed the surgery and wrote the manuscript. A.A.K. was responsible for the diagnostic procedures, treatment decisions, performed the surgery and wrote the manuscript. All the authors have read and agreed with the final version of the article.

Compliance with Ethics Requirements:

The authors declare no conflict of interest regarding this article.

The authors declars that all the procedures and experiments of this study respect the ethical standards in the

well the national law. Informed consent was obtained from the patient included in the study. No funding for this study.

Helsinki Declaration of 1975, as revised in 2008(5), as

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REFERENCES

- Shanti RM, O'Malley BW Jr. Surgical management of oral cancer. Dent Clin North Am. 2018;62(1):77-86.
- 2. Nakayama Y, Yamakawa N, Ueyama Y, et al. Examination of suprahyoid muscle resection and other factors affecting swallowing function in patients with advanced oral cancer after surgical resection and reconstruction. *J Craniofac Surg.* 2022;33(8):e840-e844.
- Zebolsky AL, Ochoa E, Badran KW, et al. Appearance-related distress and social functioning after head and neck microvascular reconstruction. *Laryngoscope*. 2021;131(7):E2204-E 2211.
- Ritschl LM, Fichter AM, Grill FD, et al. Bone volume change following vascularized free bone flap reconstruction of the mandible. J Craniomaxillofac Surg. 2020;48(9):859-867.
- Valdez JA, Brennan MT. Impact of oral cancer on quality of life. Dent Clin North Am. 2018;62(1):143-154.
- Zebolsky AL, Patel N, Heaton CM, Park AM, Seth R, Knott PD. Patient-reported aesthetic and psychosocial outcomes after microvascular reconstruction for head and neck cancer. JAMA Otolaryngol Head Neck Surg. 2021;147(12):1035-1044.
- Vermaire JA, Partoredjo ASK, de Groot RJ, Brand HS, Speksnijder CM. Mastication in health-related quality of life in patients treated for oral cancer: A systematic review. *Eur J Cancer Care* (Engl). 2022;31(6):e13744.
- Knitschke M, Bäcker C, Schmermund D, et al. Impact of planning method (conventional versus virtual) on time to therapy initiation and resection margins: A retrospective analysis of 104 immediate jaw reconstructions. *Cancers* 2021;13:3013.
- Chiapasco M, Colletti G, Romeo E, Zaniboni M, Brusati R. Long-term results of mandibular reconstruction with autogenous bone grafts and oral implants after tumor resection. *Clin Oral Implants Res.* 2008;19(10):1074-1080.
- Lonie S, Herle P, Paddle A, Pradhan N, Birch T, Shayan R. Mandibular reconstruction: meta-analysis of iliac – versus fibula-free flaps. ANZ J Surg. 2016;86(5):337-342.
- Shnayder Y, Lin D, Desai SC, Nussenbaum B, Sand JP, Wax MK. Reconstruction of the lateral mandibular defect: a review and treatment algorithm. JAMA Facial Plast Surg. 2015;17(5):367-373.
- Brown JS, Lowe D, Kanatas A, Schache A. Mandibular reconstruction with vascularised bone flaps: a systematic review over 25 years. Br J Oral Maxillofac Surg. 2017;55(2):113-126.
- Rachmiel A, Shilo D, Blanc O, Emodi O. Reconstruction of complex mandibular defects using integrated dental custom-made titanium implants. *Br J Oral Maxillofac Surg.* 2017;55(4):425-427.
- Kakarala K, Shnayder Y, Tsue TT, Girod DA. Mandibular reconstruction. Oral Oncol. 2018;77:111-117.

- Mehrotra UV, Howlader D, Singh D, Gupta PK. Patient specific three-dimensional implant for reconstruction of complex mandibular defect. J Craniofac Surg. 2019;30(4):e308-e311.
- Zhang PP, Meng L, Shen J, et al. Free radial forearm flap and anterolateral thigh flap for reconstruction of hemiglossectomy defects: A comparison of quality of life. *J Craniomaxillofac Surg.* 2018;46(12):2157-2163.
- Öhman D, Schaefer C, Nannmark U, Kjeller G, Malmström J. Mandible reconstruction with patient-specific implants: Case report of five consecutive patients. Int J Oral Maxillofac Implants. 2019;34(1):e7-e11.
- Ohkoshi A, Sato N, Kurosawa K, et al. Impact of CAD/CAM mandibular reconstruction on chewing and swallowing function after surgery for locally advanced oral cancer: A retrospective study of 50 cases. Auris Nasus Larynx. 2021;48(5):1007-1012.
- Jimenez JE, Nilsen ML, Gooding WE, et al. Surgical factors associated with patient-reported quality of life outcomes after free flap reconstruction of the oral cavity. Oral Oncol. 2021;123:105574.
- Kang YF, Ding MK, Qiu SY, Cai ZG, Zhang L, Shan XF. Mandibular reconstruction using iliac flap based on occlusion-driven workflow transferred by digital surgical guides. *J Oral Maxillofac Surg.* 2022;80(11):1858-1865.