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A Systematic Decision Algorithm for Reconstruction after External Auditory Canal Carcinoma Resection: The Specific Roles of Bilobed and Submental Island Flaps

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Abstract

Background: External auditory canal carcinoma (EACC) is a rare head and neck malignancy, and surgical resection often leaves complex defects requiring individualized reconstruction. Currently, there is a lack of standardized decision guidelines for selecting reconstructive techniques based on defect characteristics. This study aimed to evaluate the efficacy of a defect-based decision algorithm for guiding individualized reconstruction after resection of EACC, focusing on the specific indications and outcomes of the bilobed (BLF) and submental island (SIF) flaps.

Methods: A single-center retrospective study was conducted on seven consecutive EACC patients who underwent surgical treatment between April 2022 and April 2024. According to the predefined reconstructive decision flowchart, limited defects (< 2 cm^2) were directly sutured (n = 1); moderate defects (2–5 cm^2), particularly those involving the auricular helix, were treated with BLF (n = 3); and large defects (> 5 cm^2), or those involving the auricle, were treated with SIF (n = 3). Oncological, reconstructive and aesthetic outcomes were assessed, with no complex statistical tests applied due to the small sample size.

Results: All patients achieved negative surgical margins, with 100% flap survival and no complications such as necrosis or infection. The median wound healing time was 12 days (range, 10 – 14 days). Patient satisfaction with the aesthetic outcome, measured by a visual analog scale (VAS), was high in both the BLF (9.0 ± 0.8) and SIF (8.7 ± 1.2) groups. All the patients achieved negative surgical margins. During the follow-up period of 13–39 months, all patients were alive with no local recurrence or regional metastasis.

Conclusions: Adherence to a systematic decision-making algorithm based on defect size and location facilitated optimal individualized reconstruction after EACC resection. BLF is ideal for moderate defects that require conchal contour restoration, whereas SIF, with its reliable bulk and technical simplicity, is excellent for large composite defects, particularly in patients with comorbidities. This algorithm provides a standardized clinical decision framework for EACC reconstruction, with promising clinical application value for routine practice.

Keywords: External Auditory Canal Carcinoma; Bilobed Flaps; Submental Island Flaps; Reconstructive surgery; Clinical decision-making

1. Background

Carcinoma of the external auditory canal (EACC) is a rare and challenging malignancy, accounting for approximately 0.3% of all head and neck tumors(1). Surgical resection with negative margins remains the cornerstone of its treatment. However, the resulting defects are often complex and involve the skin, cartilage, and sometimes, the auricle or parotid gland, posing a significant reconstruction dilemma. The goal is not only to completely remove the tumor and cover the wound but also to preserve the function and restore an acceptable aesthetic appearance, particularly considering the prominent position of the ear on the face. Although numerous reconstructive options are available, there is a lack of consensus or systematic guidelines for selecting the most appropriate technique based on objective defect characteristics. Therefore, this study aimed to address the lack of standardized reconstructive guidelines for EACC, we developed a defect-based decision algorithm and validated its efficacy in clinical practice.

This study is the first to clarify the specific clinical indications of bilobed flaps (BLF) and submental island flaps (SIF) in EACC reconstruction, providing a practical reference for clinical surgeons.

2. Methods

2.1 Clinical Data

We retrospectively analyzed the clinical data of 7 patients with EACC who underwent surgical resection and reconstructive treatment at the Department of Otolaryngology-Head & Neck Surgery, between April 2022 and April 2024. The study strictly followed predefined inclusion and exclusion criteria: inclusion criteria were (1) pathologically confirmed primary EACC, (2) completion of lateral temporal bone resection (LTBR) and reconstructive surgery at our center, and (3) complete clinical, surgical, and follow-up data; exclusion criteria were (1) secondary EACC derived from other head and neck tumors, (2) severe systemic comorbidities that precluded surgical treatment and regular follow-up.

Among the 7 patients, there were 2 males and 5 females, with an age range of 50 to 71 years [average 60±7.2 years]. The main clinical manifestations at admission included otalgia, persistent otorrhea, and sensorineural or conductive hearing loss. All patients received a comprehensive preoperative evaluation, including electronic otoscopy, pure-tone audiometry, high-resolution computed tomography (HRCT) and magnetic resonance imaging (MRI) of the head and neck, to clarify the tumor invasion range, anatomical structure involvement, and absence of distant metastasis.

Surgical intervention was performed only after a definitive pathological diagnosis was obtained via preoperative biopsy. Pathological classification of the tumors revealed 5 cases of adenoid cystic carcinoma (ACC) and 2 cases of squamous cell carcinoma (SCC). Tumor staging followed the EACC staging standard of the University of Pittsburgh(2000)(2), and postoperative pathological results were used for correction. The detailed clinical data of the patients are presented in Table 1.

2.2 Surgical Method

This study was approved by the Ethics Review Committee of the Second Hospital of Jilin University (Approval No.20250246), and written informed consent was obtained from all patients. All patients underwent LTBR for oncological clearance. For patients with SCC, simultaneous superficial/total parotidectomy and selective neck lymph node dissection were performed according to the extent of tumor invasion.

Reconstructive strategies were strictly followed the decision flowchart shown in Figure 1, with the main bases being the postoperative defect and affected areas. For limited defects (< $2cm^2$), direct alignment suture was performed to close the external auditory canal. For moderate (2 – $5cm^2$) and localized defects of the cavum conchae (< $2cm^2$), BLF was used for reconstruction. For extensive defects (> $5cm^2$) or cases involving the auricle, SIF was used for reconstruction. The BLF pedicle was located at the posterior edge of the auricle. The SIF was harvested from the submental region with the facial artery as the vascular pedicle, with an average thickness of 1.2-1.5cm. All donor sites were closed primarily by direct suture. Comparison of characteristics between bifid flap and submental island flap in Table 2.

2.3 Outcome Measures

The primary and secondary outcome measures were pre-specified to evaluate the surgical and reconstructive efficacy: (1) Oncological outcomes: achievement of negative surgical margins, local recurrence, regional lymph node metastasis and distant metastasis during follow-up; (2) Reconstructive outcomes: flap survival rate, occurrence of surgical complications (e.g., flap necrosis, wound infection), and median wound healing time (from surgery to complete suture removal); (3) Aesthetic satisfaction: evaluated by a visual analog scale (VAS, 0–10 points, 10=highest satisfaction), completed at the last follow-up visit.

3. Results

All seven patients achieved negative margins and no lymph node metastasis. According to the defect reconstruction strategy, one case was directly sutured, three underwent BLF, and three underwent SIF. All the flaps healed in one stage without complications related to the flaps. The median wound healing time was 12 days (10 – 14 days). Patient satisfaction scores for postoperative appearance were generally high. The VAS scores (mean ± standard deviation) for the BLF (n=3) and SIF (n=3) groups were 9.0 ± 0.8 and 8.7 ± 1.2, respectively. All patients without a history of radiotherapy before the operation received radiotherapy within 4 to 6 weeks after surgery. Follow-up was conducted 13 – 39 months postoperatively. At the time of the last follow-up, all patients were still alive. Except for one patient with ACC who had lung metastasis and survived with the tumor, all other patients were tumor-free, and there was no local recurrence or regional metastasis.

4. Discussion

The primary challenge in managing EACC lies in not only achieving oncological clearance, but also in reconstructing inner ear function, aesthetics, and procedural morbidity. Given the rarity of this malignancy, reconstructive approaches have historically been guided by surgeon preferences and individual experience, rather than standardized protocols. This study introduced and preliminarily validated a defect-based algorithmic strategy for post-resection reconstruction (Figure 1). This systematic approach successfully guided the selection of the most appropriate reconstructive technique in all seven cases, resulting in 100% flap survival, no major complications, and high patient satisfaction. Although the small sample size precludes definitive statistical conclusions, consistent positive outcomes underscore the potential of the algorithm to standardize care and reduce decision-making variability. In addition, the algorithm assigns distinct roles to the BLF and SIF, leveraging their unique properties to address specific reconstruction needs.

For moderately sized defects (2 – 5cm^2), particularly those involving the conchal bowl, BLF has emerged as an ideal solution. Its design, which harnesses the laxity of the postauricular skin, offers crucial advantages for this anatomical region. First, the bilobed configuration effectively distributes tension across a broader area, minimizing the risk of tragal retraction or auricular distortion, which are common pitfalls when closing conchal defects under tension. Second, and perhaps most importantly, BLF provides an unparallel bilateraled aesthetic match. The skin from the postauricular region is nearly identical to the native periauricular skin in color, texture, and thickness, allowing for seamless integration and inconspicuous reconstruction of the delicate three-dimensional contours of the concha. In our series, performing BLF consistently restored the natural concavity of the conchal bowl, effectively preventing the "flat ear" deformity, which contributed to the exceptional patient-reported satisfaction scores (VAS 9.0 ± 0.8; Figure 2). Our favorable outcomes align with the established reliability and aesthetic superiority of BLF in periauricular reconstruction, as documented in the literature.

For larger composite defects (>5 cm^2) or cases with significant auricular involvement, SIF proved to be a robust and versatile flap. Compared with free flaps (such as the anterior thigh lateral or forearm radial free flaps), its principal strengths lie in its reliable vascular pedicle and technical simplicity(3, 4). The SIF provides an appropriate amount of soft tissue volume (average thickness of 1.2 – 1.5cm), which fills the dead spaces resulting from parotidectomy and temporal bone resection while preventing the flap from becoming bulky. The donor and recipient areas of SIF are in the same surgical field, and the procedure can be completed for sample collection and reconstruction without changing the body position. This represents a distinct advantage over other local pedicle flaps (such as the pectoralis major flaps and the latissimus dorsi flaps) or skin grafts(4, 5). Furthermore, SIF obviates the need for microvascular anastomosis, significantly reducing operative time and making it a safer option for older patients or those with significant comorbidities, as exemplified in cohorts 1 and 3 (Figure 3). The scar in the SIF donor area was concealed within the natural folds of the neck. The high satisfaction score of this group (VAS 8.7 ± 1.2) confirms that its functional benefits do not come at the cost of acceptable cosmesis. Although concerns regarding potential metastasis to level I lymph nodes have been raised(6, 7), we mitigated this risk through meticulous preoperative imaging and intraoperative frozen section analysis of the submental nodes when indicated, ensuring oncological safety. Our experience corroborates the findings of Howard, who positioned SIF as an effective and simpler alternative to free flaps in selected scenarios(4).

Beyond validating the utility of BLF and SIF, the broader significance of this study lies in its introduction of a systematic clinical decision framework. This algorithm transforms the EACC reconstruction from an artisanal experience-dependent practice into a structured, reproducible process. For rare diseases, such as EACC, where clinical experience is often fragmented, such a framework is invaluable. It provides a clear step-by-step guide for surgeons, particularly those in non-specialized centers or in training, thereby promoting the homogenization of care and potentially improving overall disease management. The flowchart serves as an excellent educational tool that demystifies decision logic and facilitates the dissemination of standardized reconstructive principles.

It is imperative to emphasize that the success of any reconstructive strategy is based on a precise preoperative diagnosis and adequate oncological resection. First, in response to the challenge of the early misdiagnosis of EACC, we emphasize the need to be vigilant for a high index of suspicion, such as atypical otalgia, bloody otorrhea, or new growths in the external auditory canal(8, 9). Second, we emphasize the significance of negative surgical margins beyond merely expanding the scope of resection. In all patients in this group, local tumor control and preservation of inner ear function were achieved through precise LTBR. This remains the cornerstone of the treatment and is a fundamental prerequisite for subsequent reconstruction.

This study has few limitations inherent to its exploratory nature. Its retrospective design, small sample size, and single-center origin limit the generalizability of the findings and preclude robust statistical comparisons. Varying follow-up durations necessitate long-term studies to assess the oncological and functional outcomes. Future prospective multicenter studies with larger patient cohorts are warranted to validate and refine this decision-making algorithm.

5. Conclusions

A defect-based decision algorithm can effectively guide individualized reconstructive surgery for EACC after resection. BLF is the first choice for medium-sized areas, especially for cases involving defects in the concha cavity. While SIF is ideal for large-area composite defects or patients with comorbidities. This algorithm provides a practical and standardized clinical decision framework for EACC reconstruction, and its long-term efficacy needs to be verified by large-sample multicenter studies.

List of abbreviations

ACC	Adenoid cystic carcinoma
BLF	Bilobed flap
EACC	External auditory canal carcinoma
HRCT	High-resolution computed tomography
LTBR	Lateral temporal bone resection
MRI	Magnetic resonance imaging
SCC	Squamous cell carcinoma
SIF	Submental island flap
VAS	Visual analog scale

Acknowledgments

Ethics approval and consent to participate

This study was approved by the Ethics Review Committee of the Second Hospital of Jilin University (Approval No.20250246). Written informed consent was obtained from all patients prior to surgical intervention, after a comprehensive explanation of the surgical procedures, potential risks and benefits, and alternative treatment options for external auditory canal carcinoma. The confidentiality and anonymity of all participant data were preserved.

Consent for publication

Written informed consent for the publication of clinical details, imaging data and surgical outcomes of the study was obtained from all participating patients.

Availability of data and materials

All data generated or analyzed during this study are included in this published article

Competing interests

The authors declare that they have no competing interests.

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Authors' Contributions

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Writing – original draft: Jie Bai;

Writing – review & editing: Xue Zhao, Guofang Guan;

Visualization: Wenjia Wang;

Supervision: Xue Zhao, Guofang Guan;

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Tables:

Table 1. Clinical Data of 7 Patients with External Auditory Canal Cancer

No	Sex	Age (years)	Symptoms	Patho-logical type	Stage	Surgical method	Margin	Tumor size (cm^2)	Repair method	Follow-up (months)	VAS
1	F	65	Otalgia、Otorrhea、Hearing loss、Diabetes	ACC	$T_4 N_0 M_0$	LTBR+TP	（-）	2*2	SIF	39,No recurrence/ metastasis	8
2	M	54	Otalgia、Ear fullness、Hearing loss	ACC	$T_1 N_0 M_0$	LTBR+SP	（-）	0.5*0.7	BLF	29,No recurrence/ metastasis	10
3	F	50	Otalgia、Otorrhea、Hearing loss、	ACC	$T_3 N_0 M_1$	LTBR+TP	（-）	2*2	SIF	28, No local recurrence, Tumor-bearing	8

			Facial palsy (H-B II) 、Pulm. metas.							survival	
4	F	51	Otalgia 、Bloody otorrhea	ACC	$T_2 N_0 M_0$	LTBR+SP	（-）	0.5*0.5	BLF	27,No recurrence/ metastasis	9
5	F	60	Otalgia 、Hearing loss、Tinnitus	ACC	$T_2 N_0 M_0$	LTBR+SP	（-）	1.5*1.5	BLF	25,No recurrence/ metastasis	9
6	F	71	Bloody otorrhea 、Otalgia 、Hearing loss	SCC	$T_3 N_0 M_0$	LTBR+SNP(II、III)	（-）	2.0*1.5	AS	13,No recurrence/ metastasis	10
7	M	67	Otalgia 、Bloody otorrhea 、Hearing loss	SCC	$T_4 N_0 M_0$	LTBR+TP+ SNP(II、III)	（-）	4.5*4.0	SIF	13,No recurrence/ metastasis	9

Notes：ACC(Adenoid Cystic Carcinoma)；SCC(Squamous Cell Carcinoma)；LTBR（Lateral Temporal Bone Resection）；SP（Superficial Parotidectomy）；TP（Total Parotidectomy）；SND（Selective Neck Dissection）；SIF（Submental Island Flap)；BLF（Bilobed Flap）；AS (Apposition Suture）

Table 2. Comparison of Characteristics between Bifid Flap and Submental Island Flap

	Bifid Flap	Submental Island Flap
Anatomical feature		
Vascular pedicle	Random flaps, without named artery and vein system	Submental artery/vein (branch of facial artery)
Tissue dose	Limited, the flap itself is relatively thin	Sufficient, capable of carrying skin, subcutaneous tissue and part of the submandibular glands, with an average thickness of 1.2 - 1.5 cm.
Flap size	Medium, usually applicable to defects of 2-5 cm² in size	Larger, repairable > 5 cm² extensive defects, up to a maximum of 7x15 cm
Clinical applicability		
Optimal applicable	A medium-sized defect involving the reconstruction of the auricular helix contour	Large-scale, multi-component defects that require extensive tissue filling of the dead space
Main advantages	Excellent aesthetic compatibility: The color, texture, and thickness are consistent with the skin around the ear.	Adequate tissue supply: Can effectively fill the parotid gland area and the postoperative dead space of the temporal bone.

	Excellent mechanical properties: The double-leaf design disperses tension, effectively preventing deformation of the earlobe.	Concealed donor site: The scar is hidden within the neck folds. Long and stable vascular pedicle: The rotational arc can easily cover the ear area.
Main limitations	The tissue volume is limited and is not suitable for large-area or deep defects. It is not applicable to those with damaged ear skin or those with tight skin.	Before the operation, the lymph nodes in area I need to be carefully evaluated. If there is a suspected positive result, frozen pathological examination should be conducted for guidance. For male patients, the donor area may contain hair.
Surgery Technology		
Microsurgical	Not required	Not required
Surgical difficulty	Medium level. Complete within the given time limit.	Moderate to high, short duration, high success rate
Donor area	Behind the ears	Regiones submentalis
Special application	Repairing the auricular cartilage to prevent the "flat ear" deformity is the preferred treatment option.	The ideal choice for elderly patients, those with comorbidities (such as diabetes), and those with a history of previous radiotherapy.

Figures:

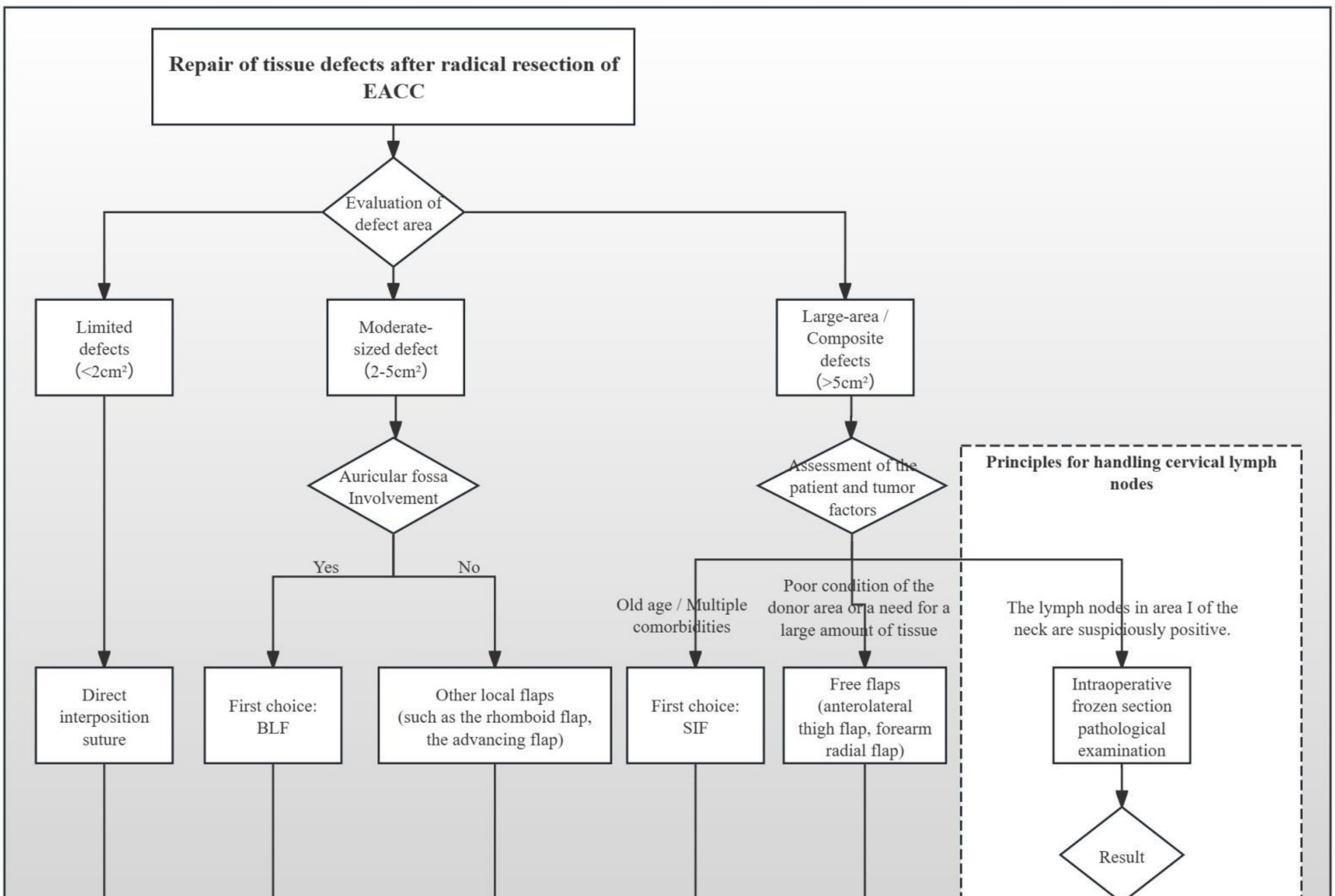

Figure 1. The flowchat of reconstruction strategy for tissue defects after EACC surgery.

Figure 2. The design and postoperative effect of the bilobed flap reconstruction

Symbols in the figure represent the following: asterisk (*), the tumor lesion; upward-pointing triangle (▲), primary flap; diamond (◆), secondary flap.

(A) Incision and flap design; **(B)** 12 month after surgery;

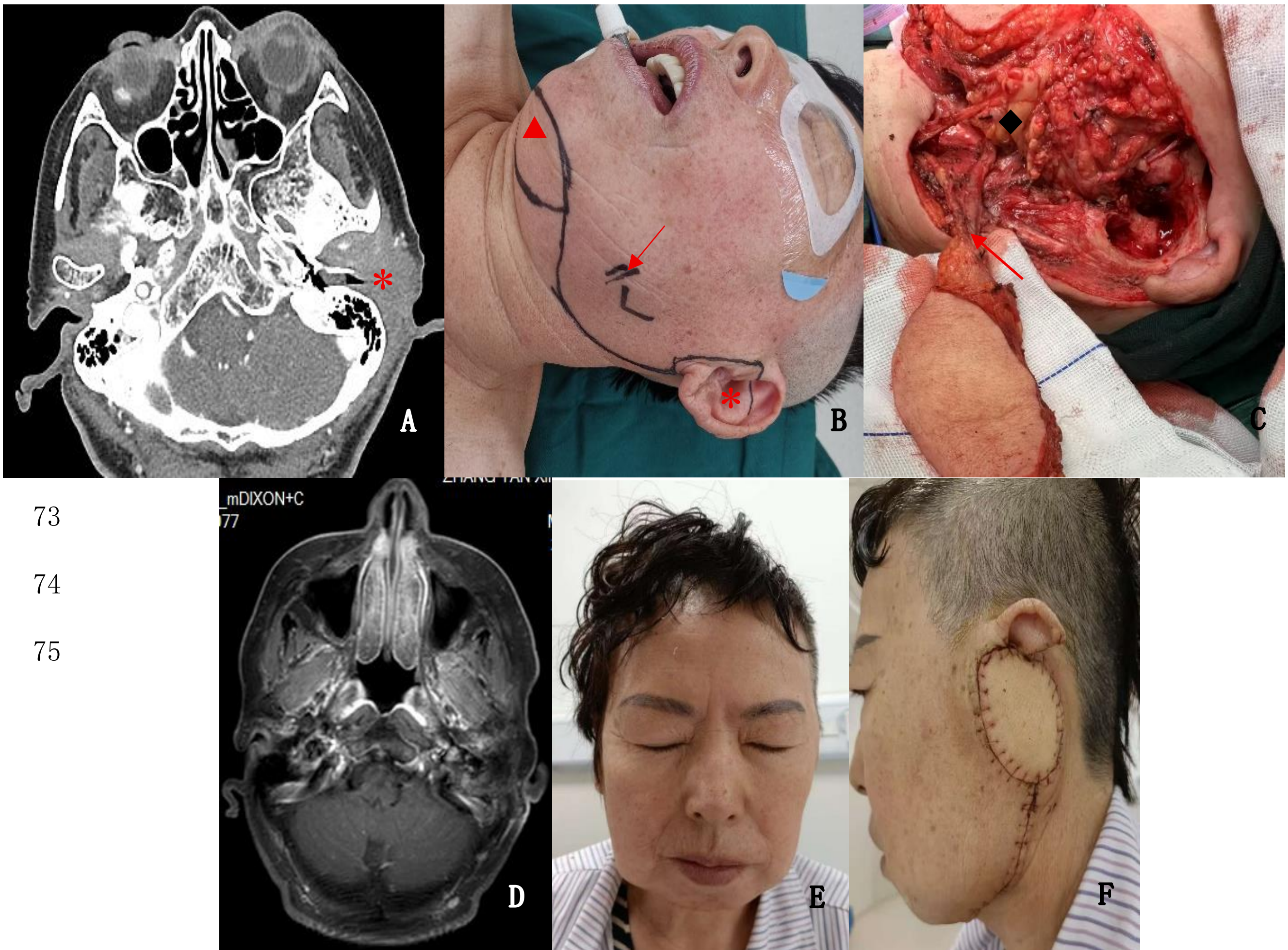

Figure 3. Surgical procedure for tumor resection and submental island flap reconstruction.

Symbols in the figure represent the following: asterisk (*),the tumor lesion; arrow(→), facial artery; diamond (◆), parotid gland; triangle (▲), submental flap.

(A) Preoperative enhanced HRCT, localizing the tumor.
(B) Intraoperative photograph showing the designed incision line and the outlined flap.
(C) Intraoperative view after tumor resection, demonstrating the resultant defect and the elevated SIF.
(D) Postoperative MRI, confirming the reconstruction.
(E) Clinical photograph of the patient (frontal view) on postoperative day 14.
(F) Clinical photograph of the patient (lateral view) on postoperative day 14.