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Application of pedicled supraclavicular flaps in hypopharyngectomy with preservation of laryngeal function

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Abstract

Objective To evaluate the efficacy of pedicled supraclavicular flaps in hypopharyngectomy reconstruction, with a focus on preserving laryngeal function.

Methods From August 2019 to June 2022, 14 patients with primary hypopharyngeal carcinoma who met the inclusion and exclusion criteria and underwent the repair of hypopharyngeal defects using pedicled supraclavicular flaps were included retrospectively. Relevant clinical evaluation indicators include patient characteristics, defect sizes, flap sizes, flap harvesting time, postoperative hospital stay, postoperative complications, recurrence, and survival outcomes.

Results Among the 14 patients, pyriform sinus carcinoma ($n = 10$) and posterior hypopharyngeal wall carcinoma ($n = 4$) were present, with stages T2 ($n = 7$), T3 ($n = 4$), T4 ($n = 3$), N0 ($n = 3$), N1 ($n = 1$), and N2 ($n = 10$). The average defect size was 7.0 (4.0–12.6) cm in the longitudinal diameter and 4.1 (2.8–7.5) cm in the transverse diameter. The mean flap size was 8.4 (5.0–14.0) cm in length and 6.5 (4.0–9.0) cm in width. The mean time for flap harvesting was 37.0 (29.0–51.0) min. The mean postoperative hospital stay was 24.0 (12.0–48.0) days. The mean follow-up period was 20.3 (4.0–47.0) months, and one of the 14 patients was lost during follow-up. Short-term postoperative complications included partial flap necrosis ($n = 1$), subcutaneous hematoma at the donor site ($n = 1$), and pharyngeal fistula ($n = 4$). Long-term complications encompassed pharyngoesophageal anastomotic stenosis ($n = 2$) and shoulder elevation dysfunction ($n = 2$). Tumor recurrence occurred in 3 patients. 1 patient succumbed to massive hemorrhage resulting from neck infection due to pharyngeal fistula during chemoradiotherapy. 2 patients succumbed to tumor-related causes. The gastric tube was removed in 13 patients, and the tracheal tube was extracted in 10 patients.

Conclusion The supraclavicular flap offers a promising alternative for reconstruction during hypopharyngectomy with preservation of laryngeal function. It can be utilized to reshape the morphology of the pyriform fossa, aryepiglottic wall, and laryngeal cavity, thereby restoring the functionality of the laryngopharynx.

Keywords Supraclavicular flap, Hypopharyngeal carcinoma, Surgery, Reconstruction, Laryngeal function preservation

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Introduction

Hypopharyngeal carcinoma, often diagnosed at an advanced stage due to non-specific early symptoms, typically spreads to adjacent tissues [1]. Comprehensive treatment includes surgical treatment and postoperative chemoradiotherapy. Currently, there is a consensus regarding retaining laryngeal function as



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much as possible during tumor resection to improve the quality of life of patients.

In terms of hypopharyngeal carcinoma, filling surgical defects and restoring swallowing function have become surgical challenges [2]. Unfortunately, there is currently no unified standard and method. Reconstruction approaches depend on the patient's systemic condition, the scope of the defect, the experience and habits of the surgeon, etc. In recent years, free flaps have often been used to close the defects after hypopharyngectomy [3, 4]. However, free flaps require advanced microscopic anastomosis techniques and long operation times, in addition to high requirements for postoperative flap care; therefore, not all centers can perform such procedures [5]. Pedicled flaps are also options in the restoration of head and neck defects and have received increasing attention. In contrast to free flaps, pedicle flaps are more straightforward in operation, do not necessitate microvascular anastomosis, shorten the operation time, and are predominantly situated in the neck area.

In recent years, supraclavicular flaps with blood supply to branches of the transverse cervical artery have been used in reconstruction after head and neck tumor resection [6]. The supraclavicular flap is located in the neck area, is thin and soft, has moderate color and texture and is easy to fold and shape. Due to these reasons, it is a valuable option for reconstruction of laryngopharyngeal defect after hypopharyngectomy with preservation of laryngeal function. In this paper, we report the experience of 14 cases of supraclavicular flap reconstruction after hypopharyngectomy with preservation of laryngeal function and evaluate the efficacy of this reconstructive approach. In the following sections, we will explore the

surgical options available for hypopharyngeal reconstruction, emphasizing techniques that maximize both function and quality of life.

Materials and methods

Clinical data

The data of patients admitted between August 2019 and June 2022 to the Department of Otorhinolaryngology-Head and Neck Surgery, Affiliated Hospital of Southwest Medical University, who underwent the repair of hypopharyngeal defects using pedicled supraclavicular flaps were included retrospectively. Inclusion criteria: (1) $18 \leq \text{Age} \leq 70$ years old; (2) The patient was pathologically diagnosed with hypopharyngeal carcinoma, with or without extension to the larynx; (3) The patient underwent partial pharyngectomy or partial pharyngolaryngectomy; (4) The defect of was closed using pedicled supraclavicular flap. Exclusion criteria: (1) Accompanied with esophageal cancer; (2) Clinical data are incomplete. The final surgical approach is decided jointly by the surgeon and the patient. Based on these criteria, a total of 17 patients were screened. Among them, 2 patients were excluded on account of coexisting esophageal cancer, and 1 patient was excluded as the clinical data related to the flap was incomplete. The data of the remaining 14 patients were analyzed. TNM staging was performed by the AJCC 8th edition. Relevant clinical evaluation indicators include patient characteristics, defect sizes, flap sizes, flap harvesting time, postoperative hospital stay, postoperative complications, recurrence, and survival outcomes. The clinicopathological data of these patients are shown in Table 1. The study was approved by the ethics committee

Table 1 The clinicopathological data of the 14 patients

Patient	Age	TNM stage	Tumor location	Defect size	Flap size
1	62 years	T ₂ N ₂ M ₀	pyriform fossa	5.5×3.5 cm	7.0×5.0 cm
2	49 years	T ₂ N ₂ M ₀	posterior hypopharyngeal wall	5.8×4.0 cm	7.0×5.0 cm
3	51 years	T ₂ N ₂ M ₀	pyriform fossa	4.5×2.8 cm	6.0×4.0 cm
4	54 years	T ₂ N ₀ M ₀	pyriform fossa	6.5×3.0 cm	8.0×4.0 cm
5	48 years	T ₂ N ₁ M ₀	pyriform fossa	4.5×3.0 cm	6.0×4.0 cm
6	57 years	T ₂ N ₂ M ₀	posterior hypopharyngeal wall	7.6×4.6 cm	9.0×6.0 cm
7	67 years	T ₃ N ₂ M ₀	pyriform fossa	6.6×3.8 cm	8.0×5.0 cm
8	58 years	T ₂ N ₀ M ₀	posterior hypopharyngeal wall	7.8×4.8 cm	9.0×6.0 cm
9	46 years	T ₃ N ₂ M ₀	pyriform fossa	9.6×5.0 cm	11.0×6.0 cm
10	46 years	T ₃ N ₂ M ₀	pyriform fossa	4.0×2.8 cm	5.0×4.0 cm
11	55 years	T ₃ N ₂ M ₀	pyriform fossa	4.7×3.0 cm	6.0×4.0 cm
12	67 years	T ₄ N ₀ M ₀	pyriform fossa	9.0×4.5 cm	10.0×6.0 cm
13	60 years	T ₄ N ₂ M ₀	pyriform fossa	12.6×7.5 cm	14.0×9.0 cm
14	66 years	T ₄ N ₂ M ₀	posterior hypopharyngeal wall	9.8×5.7 cm	11.0×7.0 cm

of the Affiliated Hospital of Southwest Medical University (Approval NO: KY2023017).

Treatment methods

Preoperative evaluations such as enhanced computed tomography (CT), magnetic resonance imaging (MRI), laryngoscopy, and gastroscopy were completed before surgery to clarify the location and scope of the tumor and the invasion of surrounding tissue. Enhanced thin-section CT of the neck was performed to understand the course and development of the transverse cervical artery. If a preoperative enhance CT disclosed a variation or absence of the transverse carotid artery or considerable lymph node metastases at the donor-side neck level V, alternative repair approaches were employed.

Surgical techniques

Thirteen of 14 patients received a supraclavicular flap for reconstruction of the hypopharynx or larynx and hypopharynx after hypopharyngectomy. The other patient underwent supraclavicular flap reconstruction following the failure of anterolateral femoral flap repair.

After tracheotomy and cervical lymph node dissection in the lateral cervical region, the tumor was resected under the premise of ensuring a safe resection margin. In order to guarantee the complete resection of the tumor, all patients underwent intraoperative frozen pathological examination of the margin. Subsequently, a supraclavicular flap was designed on the ipsilateral side of the tumor based on the size, location, and shape of the defect in the surgical area. The size of the flap was at least 1 cm larger than the defect in the surgical area so that the surgical area could be sutured without tension. In addition, care was taken to protect the transverse cervical artery and retain the external jugular vein as much as possible during neck dissection. The specific steps were as follows: (1) the skin and subcutaneous fat were incised from the distal end of the designed flap to the surface of the deltoid muscle, and the flap together with the deltoid fascia was removed retrogradely from the deltoid muscle. The course of the vessels supplying the flap was determined using the light transmission test; (2) The skin and subcutaneous tissue should be incised near the pedicle, and attention should be paid to the deep surface of the platysma muscle. During the operation, the blood supply of the pedicle should be prevented from being affected due to the deep incision; (3) when approaching the clavicle, the incision should be close to the surface of the clavicle to avoid damage to the transverse cervical artery and veins; (4) the deep branch of the transverse cervical artery was processed at the anterior border of the trapezius muscle, and the soft tissue of the supraclavicular fossa was lifted as the pedicle at the supraclavicular

region, the surface of the prevertebral fascia, and the superficial surface of the scalene anterior muscle. The flap was fully released, and the transverse cervical artery was dissected to its origin as the pedicle; (5) after the flap was completed, the distal edge of the flap was resected, or a puncture test was performed to observe the blood supply to the flap. Subsequently, the flap was transferred to the surgical area through the deep surface of the sternocleidomastoid muscle, and the position was adjusted based on the defect morphology in the surgical area before repair. The skin of the donor site was fully mobilized and subsequently sutured directly. After surgery, the dressing was applied to avoid excessive compression of the flap pedicle so as to ensure blood supply to the flap. The survival of the flap was observed under video laryngoscopy 3 and/or 7 days after surgery. The treatment and surgical procedure of one of the patients are depicted in Fig. 1.

Follow-up

Follow-up was performed at an outpatient clinic and by telephone. Outpatients underwent video rhinolaryngoscopy, CT, and MRI. The morphology of the hypopharynx and laryngeal cavity and the survival of the flap were observed through video rhinolaryngoscopy. Among the 14 patients, 1 was lost to follow-up, the mean duration of follow-up for the remaining 13 cases was 20.3 (4.0–47.0) months. To ensure airway safety, a tracheal tube was placed in postoperative patients receiving chemoradiotherapy for 3 to 6 months.

Results

Among the 14 patients, there were pyriform sinus carcinoma ($n=10$) and posterior hypopharyngeal wall carcinoma ($n=4$), with stage T2 ($n=7$), T3 ($n=4$), T4 ($n=3$), N0 ($n=3$), N1 ($n=1$), N2 ($n=10$). The average defect size was 7.0 (4.0–12.6) cm in the longitudinal diameter and 4.1 (2.8–7.5) cm in the transverse diameter. The mean flap size was 8.4 (5.0–14.0) cm in length and 6.5 (4.0–9.0) cm in width. The mean time for flap harvesting was 37.0 (29.0–51.0) min. The mean postoperative hospital stay was 24.0 (12.0–48.0) days. Short-term postoperative complications included 1 case of partial flap necrosis, and the flaps of the remaining 13 patients survived. There was 1 case of subcutaneous hematoma at the supraclavicular donor site, which healed after a dressing change. 4 patients had a postoperative pharyngeal fistula and one of them occurred during postoperative chemoradiotherapy and caused neck infection resulting in massive bleeding and death, the remaining cases were successfully treated through conservative measures. Long-term complications encompassed 2 cases of postoperative pharyngo-esophageal anastomotic stenosis, which occurred 15 months and 5 months after surgery.

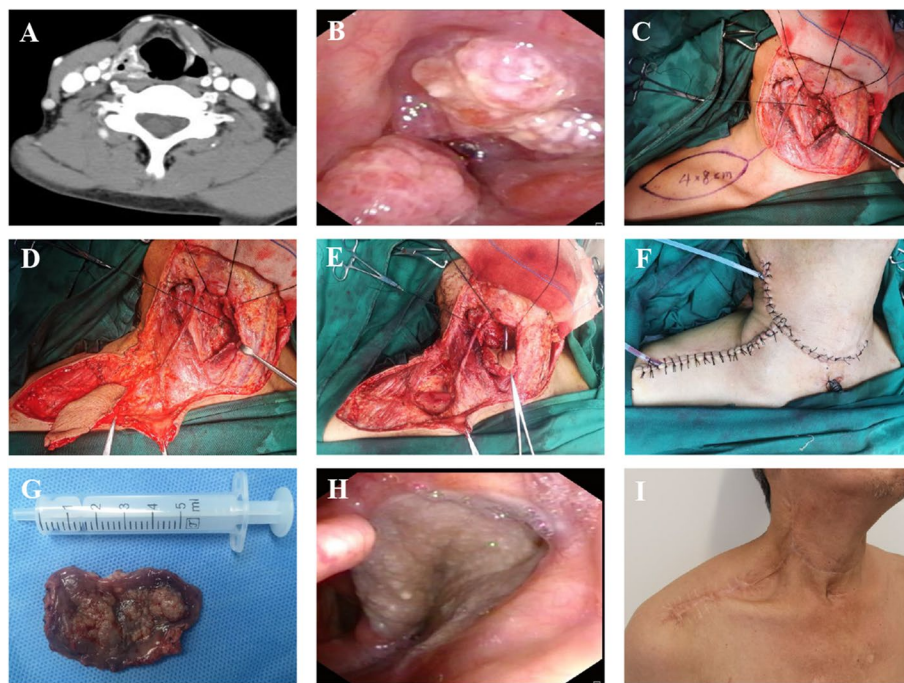


Fig. 1 The treatment and surgical process for a patient with right pyriform fossa carcinoma. **A** CT Manifestations of right pyriform fossa carcinoma. **B** Right pyriform sinus carcinoma under electronic laryngoscope. **C** After thorough resection of the tumor, design a supraclavicular flap based on the location and size of the defect. **D** Harvest supraclavicular flap. **E** Repair of right pyriform fossa and arytenoepiglottic wall with supraclavicular flap. **F** Immediate postoperative situation. **G** The resected tumor of right pyriform fossa. **H** One and a half years after surgery, the appearance of right pyriform fossa. **I** One and a half years after surgery, the appearance of neck and shoulder

Normal eating through the mouth was resumed after one dilation treatment. 2 patients presented limited shoulder elevation, which was determined to be the result of metastatic lymph nodes wrapping the accessory nerves; the metastatic lymph nodes and wrapped accessory nerves were removed together. Recurrent tumor was observed in 3 patients, 2 of whom succumbed to the disease.

All 13 patients consumed food through the oral route without a gastric tube. The tracheal tube was successfully removed in 10 patients, while tube removal failed in 2 patients due to intolerance to tube blockage. Additionally, 1 patient died during postoperative chemoradiotherapy without undergoing tracheal tube removal. The vocational function of 13 patients was satisfactory. 7 patients had mild choking and coughing after eating.

Discussion

Hypopharyngeal carcinoma accounts for approximately 5% of malignant tumors of the head and neck [7]. Its pathogenesis location is relatively hidden, the early stage lacks specific clinical manifestations, and it is prone to submucosal invasion and regional lymph node metastasis. Therefore, it is mostly discovered in the advanced stages, resulting in a poor prognosis [8, 9]. The treatment of hypopharyngeal carcinoma is often accompanied by the

loss of laryngeal function, resulting in poor quality of life for patients after surgery. To preserve laryngeal function, some patients opt for chemoradiotherapy. However, in terms of local tumor control, chemoradiotherapy alone is inferior to surgery combined with chemoradiotherapy [10]. At present, surgery in combination with chemoradiotherapy constitutes the main treatment approach, and there is a consensus among clinicians that laryngeal function should be preserved as much as possible during complete tumor resection. Effectively reconstructing the larynx to retain the function of the pharynx and laryngeal region of patients is currently an important research direction for scholars. In short, for T1 and T2 tumors in the pyriform sinus that involve the paraglottis and contralateral laryngeal, if epiglottis functions are normal, vocal cords are fixed (T3 or T4a), and contralateral vocal cord movement is normal, laryngeal function-preserving treatment can be considered if the tumor does not cross the midline. However, tumors in the pyriform sinus that invade the postcricoid region and exceed the midline, with contralateral vocal cord abnormalities and poor lung function and intolerable postoperative aspiration, are contraindicated for laryngeal function preservation [11]. Furthermore, posterior hypopharyngeal wall cancers mostly progress toward the oropharynx, esophagus,

and pyriform sinus. Even T3 tumors are less likely to involve the larynx. Therefore, it is possible to retain laryngeal function in posterior hypopharyngeal wall cancers. In general, laryngeal function can be preserved in T1 and T2 posterior hypopharyngeal wall cancers. Patients with partial selective T3 posterior hypopharyngeal wall carcinoma can also be candidates for laryngeal function preservation, but the restoration of the posterior hypopharyngeal wall is surgically challenging [3]. For carcinomas of the postcricoid region, T1-T2 postcricoid region carcinomas are indicated for laryngeal function preservation. Otherwise, when carcinomas of the postcricoid region involve a small part of the cricoid cartilage but do not involve the contralateral laryngeal and esophageal entrance, laryngeal function can be preserved. Total laryngectomy is performed when carcinomas of the postcricoid region involve the bilateral pyriform sinus and extensively involve the cricoid cartilage and laryngeal tissue through the mucosa [12].

Hypopharyngectomy with preservation of laryngeal function mainly includes open surgery and transoral surgery. Transoral surgeries mainly include transoral laser and transoral robotic surgery [13, 14]. Because of they are expensive and challenging procedures, have disadvantages because of exposure, and have a steep learning curve. Meanwhile, the depth of tumor invasion must be accurately evaluated before surgery. These factors are unfavorable to promotion and popularization, which is why open surgery is still the main method [15, 16]. Currently, the commonly used repair methods for defects after hypopharyngectomy include free flaps and pedicled flaps, and the commonly used free flaps include the radial forearm flap and the anterolateral femoral flap [17]. Additionally, patients with hypopharyngeal carcinoma involving the esophagus, the gastric pull-up may also be a surgical option for hypopharyngeal reconstruction [18]. Pedicled flaps include the pectoralis major myocutaneous flap, the thoracoacromial artery perforator flap, the submental island flap, etc [19]. Free flaps are the main flaps used because they are thin and soft, are conducive to shaping and have a large range of movement. However, the disadvantages of free flaps, including the requirement for microscopic anastomosis technology, long operation times, and complicated postoperative monitoring, are not conducive to popularization, and free flaps cannot be used for all patients [20–22]. The pectoralis major myocutaneous flap is limited due to its bulky size, difficulty in voice rehabilitation, donor site shoulder dysfunction, and decreased chest wall compliance [23]. In patients with obvious submental whiskers, the submental island flap causes obvious paresthesia in the pharynx due to beard growth at the flap after surgery [1]. The use of supraclavicular flaps in patients with ipsilateral cervical

lymph node metastasis and after radiotherapy remains controversial [24]. Supraclavicular flaps are located in the surgical area of the neck. Because the flaps are thin and soft, easy to fold and shape, and quick and easy to prepare, surgeons have begun to use them to repair and reconstruct postoperative defects after hypopharyngectomy with preservation of laryngeal function.

The supraclavicular flap, a pedicled flap supplied by the superficial branch of the transverse cervical artery, was first proposed and used in clinical practice by Lamberty in 1979 [25]. Due to the lack of anatomical studies and the high necrosis rate of the distal end of the flap, it was generally not well accepted. However, Pallua et al. conducted an anatomical study, described the vessels in 1997, confirmed the reliability of the blood supply, and thereafter, this flap was gradually utilized in clinical practice [26]. In 2009, Chiu et al. reported the use of supraclavicular island flaps instead of free flaps for repairing regional defects in the parotid gland region, thyroid region, and tracheostomy stoma in head and neck tumor surgery and noted that this flap is easy and quick to acquire, has less vascularized pedicle variation, and has lower donor-area complications, further supporting the use of these flaps [27]. In the past, defects after hypopharyngectomy of the posterior hypopharyngeal wall were mostly reconstructed using thin and easy-to-shape free forearm flaps. In addition, some scholars have used the sternohyoid muscle flap combined with the supraclavicular island flap to close hypopharyngeal defects, the sternohyoid muscle flap to restore laryngeal defects, and the supraclavicular island flap to repair hypopharyngeal defects, proposing the supraclavicular island flap combined with the sternohyoid muscle flap is safe and effective for repairing pharyngeal and laryngeal defects, with fewer complications than free flaps [28]. Pharyngoesophageal reconstruction with free jejunum or radial forearm flap as diversionary conduit can improve swallowing and aspiration [29]. The use of flaps in conjunction with a long-lasting alivary bypass stent allowed for significant reduction in the incidence of pharyngocutaneous fistula and pharyngoesophageal stricture [30]. In this group of patients, the supraclavicular flap for reconstruction of the posterior hypopharyngeal wall was used in 4 patients. Except for 1 patient who had a pharyngeal fistula and partial necrosis of the flap and was discharged from the hospital after surgery, the repair results for the remaining 3 patients were satisfactory, and the gastric tubes were removed. The tracheal tube was removed from 2 patients, but the tube was not removed from 1 patient who died of massive hemorrhage due to a neck infection caused by pharyngeal fistula during chemoradiotherapy. In addition, the gastric tube was removed from the other 10 patients with pyriform sinus cancer after supraclavicular flap repair.

The tracheal tube was removed from 8 patients. All 13 patients were followed up after surgery. Video laryngoscopy disclosed that after reconstruction, the pyriform sinus and hypopharynx were capacious, the anatomical structure of the laryngeal cavity was favorable, breathing was unimpeded, eating was normal, pronunciation met the requirements of daily life, and satisfactory reconstruction outcomes were achieved.

Based on this group of patients, it is concluded that the supraclavicular flap has the following advantages with regard to defect reconstruction after hypopharyngectomy with preservation of laryngeal function. (1) The hypopharynx is involved in the functions of swallowing, breathing and pronunciation and is relatively narrow. The supraclavicular flap is thin, soft, and easily foldable and shapeable. Therefore, it can be used effortlessly to repair and reconstruct the wide pyriform sinus and the aryepiglottic wall to prevent or reduce postoperative aspiration and restore swallowing function after surgery. (2) The supraclavicular flap is moderately thick, close to the thickness of the pharyngeal mucosa. Therefore, it can be a good tissue for reconstructing the pharyngeal cavity and the entrance of the esophagus. (3) The thinner flap can replace the free flap to some extent, thus simplifying surgical procedures, shortening surgical times, and reducing surgical difficulty and trauma. (4) The donor site can be closed and sutured directly, with fewer complications, and does not affect the function of the upper limb and shoulder, and the donor site heals well after surgery [31]. (5) The flap is easy to prepare, master, and popularize. (6) If necessary, the blood vessels at the pedicle can be exposed to make an island flap to increase flap mobility. However, the supraclavicular flap also has disadvantages, e.g., a relatively small amount of tissue and fat and lymphatic tissue present in the pedicle. For reconstruction after hypopharyngectomy with preservation of laryngeal function, in this group of patients, intraoperative tumor resection and hypopharynx and larynx restore with a free anterolateral femoral flap were performed during the same period for patient 7, and the free anterolateral femoral flap was used for hypopharyngeal and laryngeal reconstruction. After free flap repair failure, a supraclavicular flap was used for restoration. Previous studies have noted that there is no significant difference between supraclavicular flaps and free flaps in flap area or the incidences of perioperative flap necrosis, and donor site dehiscence. Compared with free flaps, supraclavicular flaps require shorter operation times and have the same efficacy as free flaps do [32]. Reconstruction should be planned considering comprehensive factors, such as the systemic condition of the patient, the extent of the lesion, the surgeon's surgical skills, and personal habits. On this basis, a reconstruction that can be completed

with the least trauma, that is the easiest to perform, and that is well accepted by patients is undoubtedly the optimal repair choice.

Conclusions

In summary, the supraclavicular flap is thin and soft, can be folded and shaped easily, is simple to prepare, and is conducive to popularization. It can act as an efficient tissue substitute for the morphology of the pyriform fossa, aryepiglottic wall, and laryngeal cavity in reconstruction following hypopharyngectomy while preserving laryngeal function to restore the function of the laryngopharynx.

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Authors' contributions

Weihua Zhou and Gang Qin: conception and design of the research. Junliang Li: acquisition of data and writing of the manuscript. Huajun Feng: critical revision of the manuscript for intellectual content. Shengen Xu: statistical analysis. Tianzhen Liu: acquisition of data. Dingting Wang: statistical analysis. All authors reviewed the manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request. Data requests can be made to Gang Qin via this email: qing_lzmc@163.com.

Declarations

Ethics approval and consent to participate

The study was approved by the ethics committee of the Affiliated Hospital of Southwest Medical University (Approval NO: KY2023017). And the study was performed in accordance with the principles stated in the Declaration of Helsinki. All patients were managed with standard of care; and the parents or guardians of the patients were thoroughly informed about the procedure, its associated risks, and complications before the surgery. The study obtained informed consent from all participants or their legal guardians.

Consent for publication

Written informed consent was provided by all participants or legal guardians allowing the publication of any identifying images and personal or clinical information related to them in this study.

Competing interests

The authors declare no competing interests.

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