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ORIGINAL ARTICLE
Reconstructive

Thyroid Gland Flap for Minimally Invasive Reconstructive Head and Neck Surgery

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Background: Head and neck surgery sometimes causes small defects, and salvage surgery after chemoradiotherapy poses some risk because of damage to the surgical site from the previous treatment. We have developed a novel thyroid gland flap for head and neck surgical reconstruction and here we describe elevating the flap, including arc rotation, size, and suture technique, and our outcomes to date.
Methods: Thyroid gland flap reconstruction was performed in 13 cases (11 patients) between July 2009 and May 2020. The clinical importance and adverse effects of the procedure were examined. Thyroid function and blood flow of the flap were assessed, and the status of the flap and irradiated recipient tissue was examined histopathologically.
Results: Median age at surgery was 64.6 years (range 49–77 years). Two of the patients underwent reconstruction with a thyroid gland flap twice. There were 4 cases of primary head and neck cancer resection with neck dissection in which the flap was harvested from the thyroid gland as reinforcement. In 1 case, surgery was performed for cervical esophageal diverticulum. In all cases, the arc was limited to 6 cm and suturing was basic. There were no complications of the surgical procedure, and the postoperative course was uneventful. Contrast-enhanced computed tomography revealed adequate enhancement of the flap. Postoperative thyroid function was normal. The thyroid gland flap was firmly adapted and fused with the irradiated recipient tissue.
Conclusion: The thyroid gland flap could be an effective tissue flap fed by the superior thyroid arteriovenous pedicle for head and neck reconstruction. *(Plast Reconstr Surg Glob Open 2020;8:e3297; doi: 10.1097/GOX.0000000000003297; Published online 17 December 2020.)*

INTRODUCTION

The thyroid gland is an endocrine organ located around the cricoid cartilage in the inferior aspect of the anterior neck.[1] It produces the thyroid hormones thyroxine (T4), triiodothyronine (T3), and calcitonin, and is fed by the superior and inferior thyroid arteries. The superior thyroid artery is the first branch of the external carotid artery; therefore, the gland has sufficient arterial flow. The superior thyroid artery is widely used in free flap reconstructive surgery and microsurgery.

The head and neck region contains important organs, including the tongue, pharynx, larynx, and thyroid gland.[2] The neck, in particular, has many vital anatomic structures, including the carotid arteries, jugular veins, cranial nerves, the muscle, and the skin.[3] Therefore, preservation of function is an important consideration of head and neck surgery. Furthermore, head and neck surgery sometimes causes defects of the oropharynx and neck tissues,[4] which, if connected to the neck, may result in fistula. Saliva could leak from the oral cavity down to the neck, causing deep neck infection and potentially life-threatening conditions such as rupture of the jugular vein and carotid artery within the carotid sheath.[5] Precise closure and reconstructive procedure is necessary in head and neck surgery.[6,7] Free or musculocutaneous flaps are used in surgical reconstruction for advanced primary cancers of the head and neck region.[8] These interventions, while definitive, are often invasive, time-consuming, cost-intensive, and can involve another operative field. If the primary defect is small, direct suturing could likely achieve adequate wound closure, but suturing has some attendant risks as well. Therefore, reinforcement tissue with sufficient blood supply is needed to support the inferior aspect. Conventional free flaps or musculocutaneous

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flaps are large; so a novel, smaller, and more appropriate flap is needed.

Chemoradiotherapy is gaining importance as a means of preserving function, especially in laryngeal and hypopharyngeal cancer.[9] Salvage surgery is needed if the cancer relapses, but it can be unsafe because the surgical site has already been markedly damaged by previous chemoradiotherapy. In the event of infection or leakage, tissue necrosis can occur and may ultimately lead to carotid rupture and septic shock.[10–12] From the perspective of head and neck oncology, avoiding this complication will require a novel flap that is reliable, simple to create, optimally sized with good blood supply, and easily adaptable.

We hypothesized that the cut edge of the thyroid gland could be used as a novel tissue flap because of its adequate arterial supply. This superior thyroid artery pedicle would allow for adequate perfusion, and by extension, adequate exposure to prophylactic antibiotics with enhanced wound healing following repair. We therefore used this thyroid gland flap for salvage head and neck surgery.[13–15] The method uses the same surgical site and the flap can be raised by the head and neck surgeons themselves.

Here, to clarify the suitability of the thyroid gland flap for minimally invasive reconstructive head and neck surgery, we report our experience in a total of 13 cases, describing the details of the methods used and the subsequent adaptation of the thyroid gland flap to recipient tissue, from a histopathological perspective.

PATIENTS AND METHODS

Patients

We performed thyroid gland flap reconstruction 13 times in 11 cases (9 men, 2 women; median age at the time of surgery, 64.6 years; age range, 49–77 years) between July 2009 and May 2020 at our institution. Indications for the procedure were as follows: (1) oropharynx connected to the neck, but direct mucosal suturing is expected to be possible; (2) salvage surgery following chemoradiotherapy for recurrent hypopharyngeal or laryngeal cancer; and (3) surgical treatment of esophageal diverticulum with muscle layer defect. Exclusions were cases where the defect was expected to be large and for which the plastic surgeon would need either a free or local musculocutaneous flap. Case distribution in terms of primary procedure was as follows: 4 cases of primary head and neck cancer resection with neck dissection; 5 cases of salvage partial laryngectomy; 1 case of hypopharyngeal cancer; and 1 case of cervical esophageal diverticulum. Primary head and neck cancer resection with neck dissection was T2, with neck metastasis in all cases. These procedures all left a small primary defect; so primary suturing was performed. However, there was strain and therefore a thyroid gland flap was adapted from the neck (Fig. 1).

Five cases of salvage partial laryngectomy had previously been treated with irradiation, chemoradiotherapy, or neoadjuvant chemotherapy followed by chemoradiotherapy. The thyroid gland flap was reused in 2 cases. One case involved recurrence after salvage partial laryngectomy with the adapted thyroid gland flap for which we performed horizontal partial laryngectomy as cricohyoidepiglottopexy (CHEP) using the initial thyroid gland flap. The other case involved previous salvage partial laryngectomy but, due to severe aspiration, we performed total laryngectomy using the initial adapted thyroid gland flap to prevent leakage through the mucosa. The case of hypopharyngeal cancer was managed as salvage partial laryngopharyngectomy (ie, previously treated with chemoradiotherapy for esophageal cancer). The above 12 cases were pathologically diagnosed as squamous cell carcinoma.

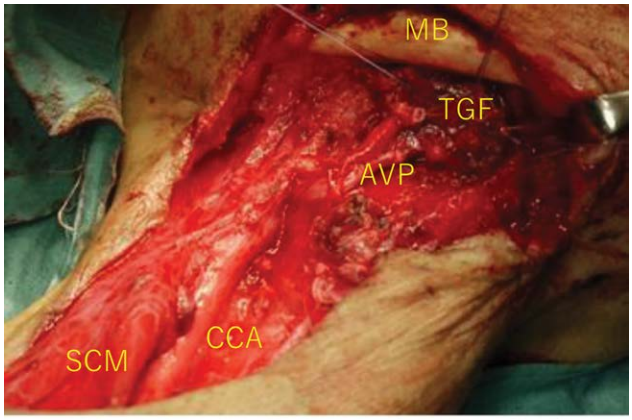
For the single case of cervical esophageal diverticulum, the thyroid gland flap was used as a patch to cover a residual esophageal muscle layer defect.

Surgical Methods

Figure 2 shows the schematic representation of elevating and adapting the thyroid gland flap. The thyroid gland flap is adapted for partial pharyngolaryngectomy. Irradiated thyroid cartilage is reused to create the optimal height of the arytenoid, but this poses some risk of necrosis due to poor blood flow. The operative photographs show how the thyroid gland flap is adapted, with adequate blood flow from the superior thyroid artery. The superior lobe of the thyroid gland is elevated while preserving the superior thyroid arteriovenous pedicle (Fig. 3), and the appropriately-sized thyroid gland flap is then raised while protecting the pedicle (Fig. 4). The flap is then inserted into the defect space (Fig. 5) and the fascial membrane of the thyroid gland is sutured firmly to the surrounding tissue.

The length of the superior thyroid artery is about 6 cm[16]; so the thyroid gland flap can be safely adapted to reach to the superior aspect of the neck (Fig. 1). The rotational arc is limited by the condition of the veins because the flap is elevated as an arteriovenous pedicle.

Usually this flap is indicated for reconstruction of small defects; so only the superior aspect of the thyroid is



Thyroid gland flap was adapted for the right side submandibular defect.

Fig. 1. The thyroid gland flap (TGF) is extended to the upper aspect for proper adaptation to the neck defect. MB, mandible bone; AVP, anteriovenus pedicle; CCA, common corotid artery; SCM, sternocleidomastoid muscle.

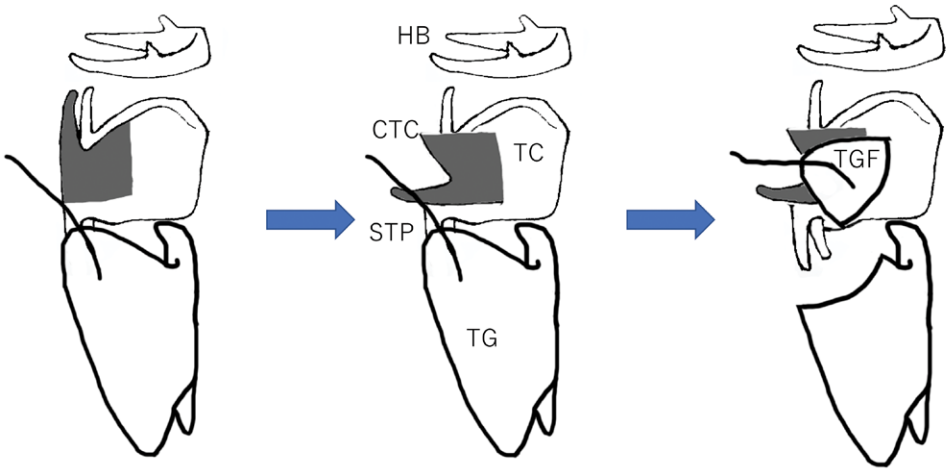


Fig. 2. TGF adapted for partial pharyngolaryngectomy. The irradiated thyroid cartilage was reused to create the height of the arytenoid. This TGF could be a good flap with optimal blood flow for this cartilage with typically poor blood supply. HB, hyoid bone; TC, thyroid cartilage; CTC, cut thyroid cartilage; STP, superiod thyroid pedicle; TG, thyroid gland.

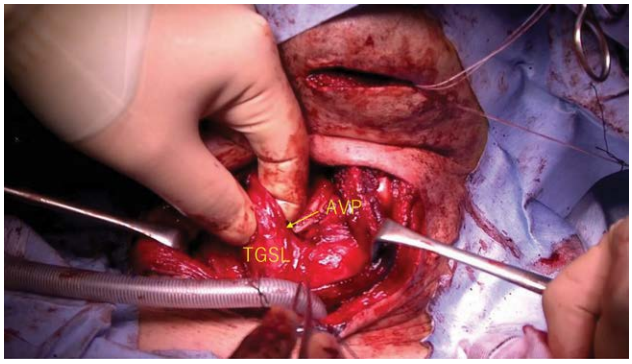


Fig. 3. The superior lobe of the thyroid gland is elevated, preserving the superior thyroid arteriovenous pedicle. TGSL, thyroid gland superior lobe; AVP, anteriovenous pedicle.

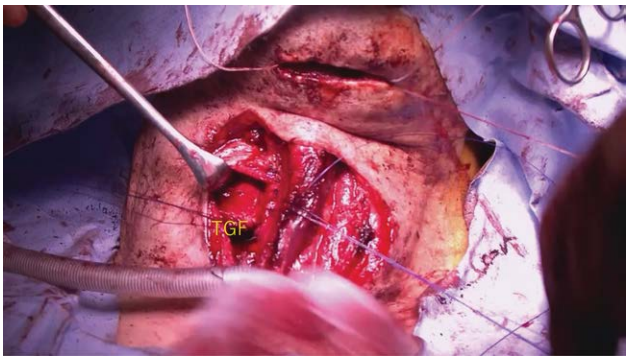


Fig. 5. The TGF is inserted into the defect space and its tissue with fascia is firmly sutured to the surrounding tissue to anchor the flap.

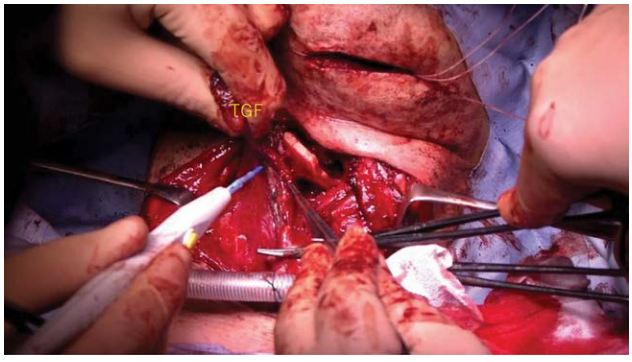


Fig. 4. While protecting this pedicle, the TGF is elevated and rotated to an appropriate orientation.

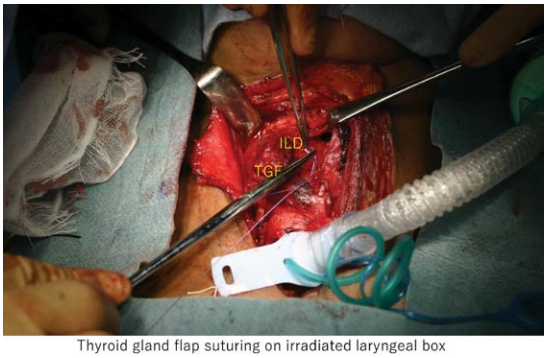


Fig. 6. The TGF is sutured to the irradiated laryngeal defect (ILD).

needed in most cases. The superior part is mainly supplied by the superior thyroid artery, and this allows for the flap to be adjusted and appropriately-sized by reducing the cut edge surface of the thyroid.

A 3-0 absorbable suture is applied to the thyroid gland fascia with tissues and the surgical defect surface (Fig. 6). Sometimes it may be sutured with the skin over the flap (Fig. 7).

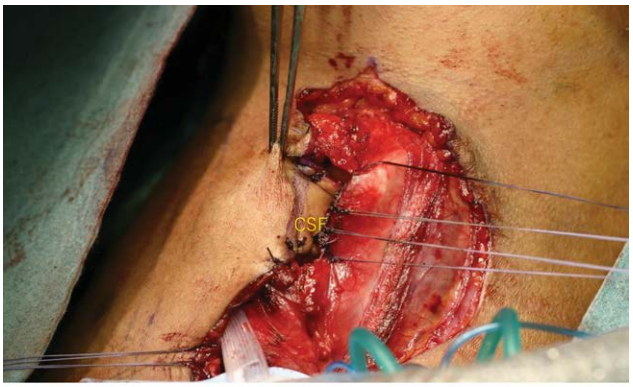


Fig. 7. Cervical skin flap (CSF) is then sutured over the TGF.

Evaluation of the Surgical Methods

We evaluated our procedure for the thyroid gland flap specifically in relation to the following: blood flow in the transferred thyroid gland flap using contrast-enhanced computed tomography; thyroid function using blood tests; adverse effects; and flap adaptation and connection with the irradiated recipient tissue.

As flap adaptation and connection was examined pathologically, this study was approved by the Aichi Medical University Medical School Research Implementation Committee (Approval No. 2015-H011).

RESULTS

Table 1 shows the data for all 13 cases of head and neck surgery with reconstruction using the thyroid gland flap that we performed between July 2009 and May 2020. There were 2 cases where the flap was used twice; so the total number of patients was 11.

Blood Flow in the Transferred Thyroid Gland Flap

CT revealed clearly enhanced thyroid gland flaps, indicating adequate blood flow from the transferred thyroid gland flap, even in the 2 cases of reuse (Fig. 8).

Thyroid Function

Postoperative thyroid function was assessed in all cases, and there were no cases of decreased free T4 (fT4). In total, 7 cases were irradiated, but these also showed no decreased fT4.

Adverse Effects of the Thyroid Gland Flap

The thyroid gland flap was completely adapted to the recipient site using the usual surgical procedure in all cases. The residual donor thyroid gland was sutured on the cut edge, and there were no adverse effects with no complications of the surgical procedure. The postoperative course was good. There was no recurrent laryngeal nerve paralysis or leakage from the oral cavity to the neck. There was also no bleeding from the surgical site postoperatively. In the salvage laryngectomy and laryngopharyngectomy cases, there were no surgical site complications such as thyroid cartilage infection or necrosis even after high-intensity chemoradiotherapy.

In the single case of reconstruction for hypopharyngeal cancer, the arytenoid height reconstruction was constitutive, and this improved the patient's quality of life in terms of swallowing (Fig. 9). The patient resumed eating on postoperative day 1515. In the single case of diverticular surgery, the patch was adjusted with no complications.

Flap Adaptation and Connection

One of the cases in which we reused the thyroid gland flap was Case 1 (shown as Case 1 and Case 3 in Table 1). In this case, when laryngeal cancer initially recurred after neoadjuvant chemotherapy and subsequent chemoradiation, we performed vertical partial laryngectomy, and when it re-recurred, we performed cricohyoidepiglottopexy (CHEP; horizontal partial laryngectomy) using the first thyroid gland flap again. This was the third cancer arising from the cervical esophagus; so total pharyngolaryngectomy was performed with cervical esophagectomy. To determine the thyroid gland flap status in relation to the recipient site, we performed hematoxylin-eosin (HE) staining, which showed thickening of the vascular wall of the vascular cavity. We considered this a "vascular cavity"

Table 1. Details of 13 Cases of Head and Neck Reconstructive Surgery Using the Novel Thyroid Gland Flap (11 Patients)

Case	Gender	Age	Primary Site	Stage	Histopathological Type	Previous Treatment	Date of Surgery	Surgery
1	M	55	Laryngeal cancer	T2N0M0	SCC	NAC→CCRT	2009/7/22	Salvage laryngectomy
2	F	40	Tongue cancer	T2N1M0	SCC	—	2012/4/16	Pharynx closure adapting
3	M (same as case 1)	60	Laryngeal cancer	rT2N0M0	SCC	NAC→CCRT	2012/12/19	Second time CHEP
4	M	73	Laryngeal cancer	T1aN0M0	SCC	NAC→CCRT	2015/4/22	Salvage laryngectomy
5	M	75	Laryngeal cancer	T1aN0M0	SCC	RT	2016/3/23	Salvage laryngectomy
6	M	65	Laryngeal cancer	T2N0M0	SCC	CCRT	2017/5/15	Salvage laryngectomy
7	M	74	Oropharyngeal cancer	T2N2aM0	SCC	NAC	2018/12/26	Pharynx closure adapting
8	M	59	Hypopharyngeal cancer	T1N0M0	SCC	CCRT	2019/1/1	Salvage laryngopharyngectomy
9	M (same as case 5)	77	Laryngeal cancer	rT2N0M0	SCC	RT	2019/2/7	Second time total latryngectomy
10	F	65	Oropharyngeal cancer	T2N2M0	SCC	NAC	2019/2/27	Pharynx closure adapting
11	M	76	Tongue cancer	T2N1M0	SCC	—	2019/2/27	Pharynx closure adapting
12	M	72	Laryngeal cancer	T1N0M0	SCC	RT	2019/10/23	Salvage laryngectomy
13	M	49	Esophagus diverticulum	—	Diverticulum	—	2020/5/18	Patch for muscle defect

CCRT, concurrent chemoradiotherapy; CHEP, cricohyoidoepiglottopexy; NAC, neoadjuvant chemotherapy; SCC, squamous cell carcinoma.

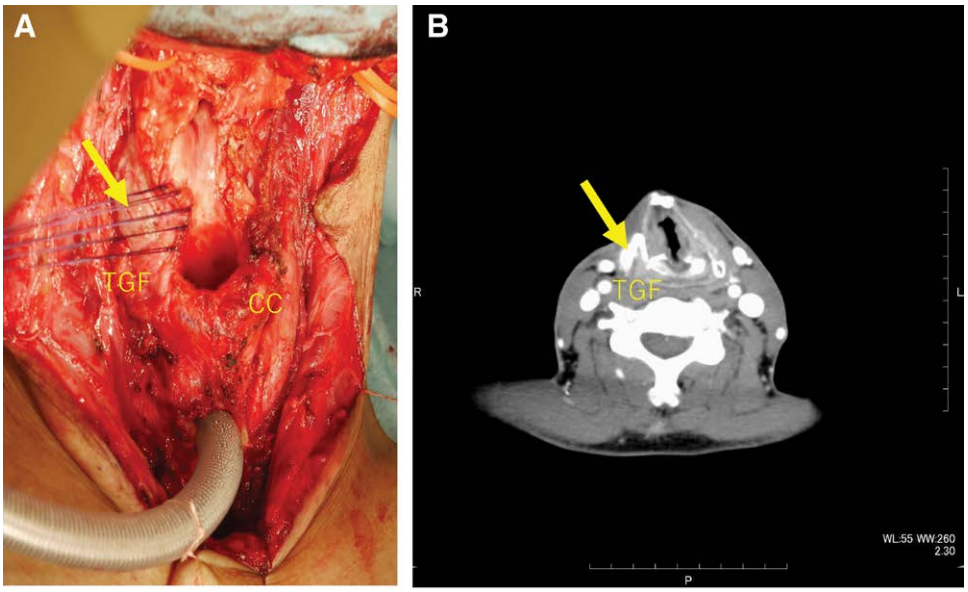


Fig. 8. A case of TGF reconstruction performed twice. The flap is clearly enhanced, revealing that the flap can be used a second time, if necessary. CC, cricoid cartilage.

after irradiation therapy.[17,18] The transferred thyroid gland was confirmed to be adapted appropriately and to be firmly fused with the vascular cavity and laryngeal tissue (ie, the irradiated recipient tissues). This case indicates that thyroid gland flap vessels might be connected to the laryngeal tissue through the vascular cavity, after irradiation (Fig. 10).

DISCUSSION

Head and neck surgery sometimes causes defects in the head and neck region. Adequately covering this defect involves the use of a free or local musculocutaneous flap, especially for large defects. These flaps are too large and the procedures are too invasive for their use in small defects. Therefore, here we have reported the procedure and outcomes of using a novel thyroid gland flap for the reconstruction of small head and neck defects in 13 cases involving 11 patients.

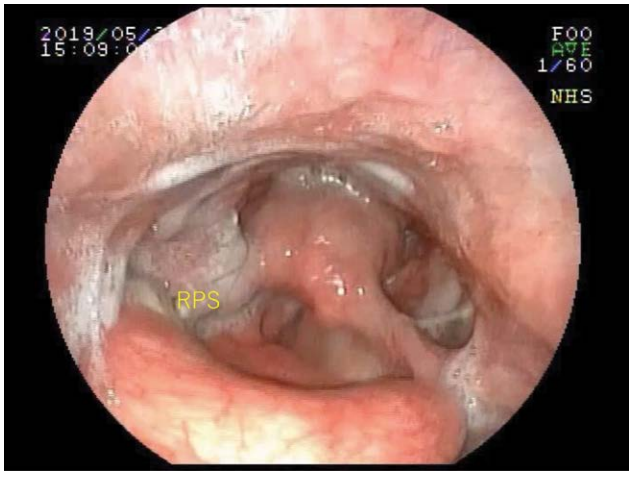


Fig. 9. Reconstructive surgery for hypopharyngeal cancer. Arytenoid height reconstruction improved quality of life in terms of swallowing. RPS, reconstructed pyriform sinus.

The procedure was performed safely in all cases and there were no complications even though the oldest patient was aged 77 years. This suggests that the thyroid gland flap is safe and can be used in a wide age-range of patients, including the elderly. Flap elevation is easy by following the course of the superior thyroid artery and vein within the same operative field. For elderly patients, given that surgery should be as minimally invasive as possible and within a small operative field, this thyroid gland flap is ideal. There were 4 cases of primary head and neck cancer resection with neck dissection, resulting in fistula extending from the oropharynx to the neck. Primary closure can be effective but sometimes the sutures break down. Here, we achieved a successful adaptation of the thyroid gland flap from the neck, as wound reinforcement (Fig. 1). Thus, use of a thyroid gland flap appears to be a viable option for reinforcement.

Cervical esophageal diverticulum resection left a large defect of the muscle layer and esophageal mucosa. Direct mucosal suturing might cause stress and complications of perforation and stenosis.[19] We used the thyroid flap to cover the mucosal surface with no resulting complications. The thyroid gland flap may therefore also be an option following cervical diverticulum resection.

The surgical defect was almost T1-2 in size in 12 of our 13 cases. This indicates that the thyroid gland flap is suitable for small primary surgical defects in terms of both small and abundant blood flow. Also, this flap can easily be elevated by head and neck surgeons as well as by plastic

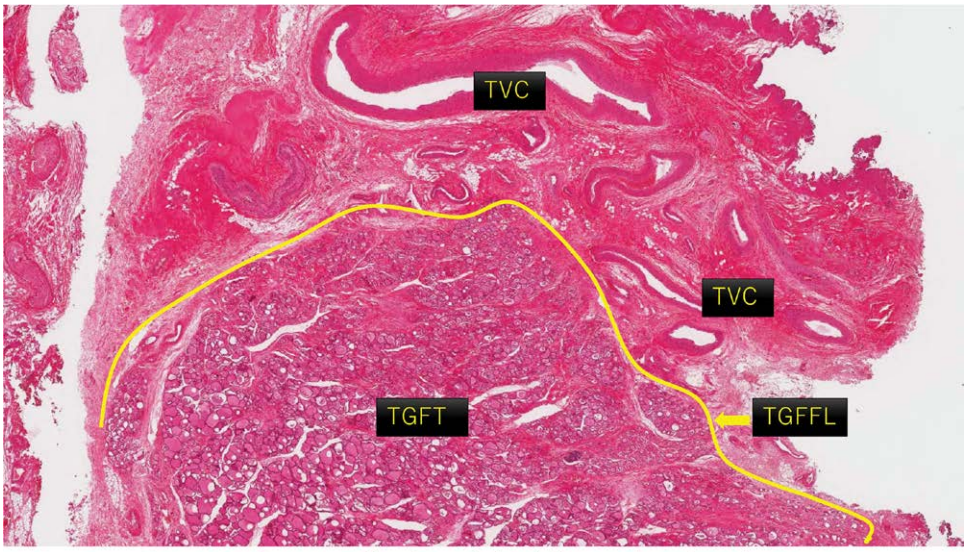


Fig. 10. Confirmed adaptation of the transferred thyroid gland with the vasculature and laryngeal tissue. There is some possibility that the thyroid gland flap vessels might be connected to the laryngeal tissue via the vascular cavity after radiation treatment. Line indicates the edge of the thyroid gland flap. TGFT, thyroid gland flap issues; TGFL, thyroid gland flap front line; TVC, thickened vascular cavity.

and reconstructive surgeons in the same operative field. The flap extends to an area of almost 6 cm[16] due to, and depending on, the length of the superior thyroid artery. The rotational arc is limited by the condition of the arteriovenous pedicle, and the flap can be moved from the laryngeal region to the superior aspect up to the submandibular region. This further highlights the usefulness of this flap. We speculate that the maximum size is probably around 40 mm because the anteroposterior diameter of the thyroid has been reported as 33–42 mm.[20] As such, the thyroid gland flap appears suitable for small to medium-sized head and neck defects.

The flap is sutured using 3-0 absorbable sutures. The thyroid fascia with tissues and surface of the surgical defect can be sutured and can also be covered by placing the skin over the flap. Therefore, the thyroid gland flap could also be used as a lining for the cervical skin (Figs. 6, 7).

There were no complications of the surgical procedure, and the postoperative course was good. The thyroid gland flaps were completely adapted to the neck defects and prevented leakage, thyroid cartilage infection, and necrosis even after high-intensity chemoradiotherapy. Particularly in the case of reconstruction for hypopharyngeal cancer, the arytenoid height reconstruction was constitutive, and this improved quality of life in terms of swallowing[15] (Fig. 10). For these reasons, we believe the thyroid gland flap is safe for use in head and neck reconstruction.

Postoperative thyroid function was assessed by measuring fT4 and showed no decreases in any of our cases. The thyroid gland was detached and transferred for use as a flap, and because the gland itself was histopathologically confirmed to have been engrafted at the site where it was implanted, we believe there will be no resulting hypothyroidism. Also, hypothyroidism did not occur among any of the 7 cases of total irradiation. These were all T1-2 laryngeal or pharyngeal disease; so the field of high-intensity chemoradiotherapy was not included in the thyroid area. The thyroid gland was not highly irradiated; so thyroid gland function was not impaired. There is, however, some possibility of hypothyroidism in the future, which could then be treated with oral thyroid hormone therapy.

Thyroid flap enlargement is another concern in the reconstructed area, but this has not been observed in our series to date. Should this occur in the future, we consider that thyroid-stimulating hormone suppression therapy would be effective for recovery of status because the thyroid gland flap has normal follicular cells.

Recurrent laryngeal nerve paralysis is also an important concern in elevating the thyroid gland flap. The flap is usually raised from only the upper lobe of the thyroid gland. Because the recurrent laryngeal nerve enters the larynx via the inferior cricoid cartilage, when elevating the upper lobe of the thyroid gland only, there is a low risk of paralysis even without proactively checking for the recurrent laryngeal nerve. When elevating a larger flap, monitoring the nerve intraoperatively might be necessary for its preservation.[21]

There were 2 cases in which the initial adapted thyroid gland flap was used in the second reconstruction. This is important in practice. One case involved a second horizontal laryngectomy with resulting successful voice preservation and closure of tracheostoma. Contrast-enhanced CT showed adequate enhancement despite this flap being used a second time, revealing that the blood flow is good even on reuse (Fig. 8). The other case involved re-covering the pharyngeal mucosa after total laryngectomy. The patient initially received irradiation therapy but the cancer recurred; so salvage laryngectomy was done. Covering this mucosa after high-intensity irradiation therapy is very difficult and sometimes leakage results. There are reports on

using a local flap for coverage, such as a pectoralis major myocutaneous flap,[22,23] but this is sometimes large and too invasive for the patient. In this second case, the initial thyroid flap was firmly connected to the recipient tissue; so we removed the attached thyroid gland flap using a cold knife and an electronic scalpel and then re-attached the thyroid gland flap at this site with no complications. We think that our novel thyroid gland flap is useful for reconstructive surgery in such cases, and further studies should examine re use of the thyroid gland flap for the second time.

We also confirmed that the thyroid gland flap was firmly adapted and fused with the irradiated recipient tissue by checking hematoxylin-eosin findings at the microscopic level. Reports revealed that this vascular status was indicative of the post-irradiation status.[17,18] We have demonstrated here the possibility that the thyroid gland flap vasculature might be connected to the laryngeal tissue through the vascular cavity after irradiation therapy (Fig. 10). This indicates the utility of the thyroid gland flap for salvage surgery after chemoradiotherapy. If saliva leakage occurs, this might worsen the general condition, but hematoxylin-eosin results showed the adapted thyroid gland flap to be connected to the irradiated recipient site, such that the flap serves as a new source of blood supply directly from the superior thyroid artery. This is beneficial for the recipient high-risk tissue in preventing severe tissue damage and necrosis. Thus, our newly conceived thyroid gland flap is considered greatly beneficial due to the superior thyroid artery attaching to the irradiated tissue, which is advantageous especially in salvage surgery for head and neck cancer.

CONCLUSIONS

We have described the utility of thyroid gland flap in head and neck surgery for T1-2 defects and also in salvage surgery for cervical esophageal diverticulum. Creating the flap is safe because it is in the same surgical field and can be done by either a head and neck surgeon or a plastic surgeon. The blood flow is rich, and the flap has good mobility due to the long superior thyroid artery, which extends to most parts of the head and neck region. No functional disorder is associated with the use of this flap, which is readily adaptable to residual irradiated tissue even on second use. Further study is anticipated by head and neck surgical oncologists and by plastic and reconstructive surgeons, and this flap may become a standard local flap for head and neck reconstruction in the future.

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