Complex reconstruction technique applied in advanced head and neck cancer

Weigang Gan, MD1, Yu Xiang, MB2, Dan Lv, MD3, Jun Liu, MD3, Haiyang Wang, MD3, Di Deng, MD3, Ji Wang, MB3, Linke Li, MM3, Tengfei Ma, MD3, Shixi Liu, MD3, Fei Chen, MD3

Abstract
Complex reconstruction skills in advanced head and neck cancer (HNC) could resolve the key problem of large defects after tumor resection. We combined the anterolateral thigh free flap, fascia lata flap, and greater saphenous vein graft in the reconstruction process of salvage surgery. Seven patients suffering from advanced HNC who experienced the failure of multiple therapeutic methods were enrolled in our study between June 2017 and January 2018. They all agreed to voluntarily undergo the tumor excision and complex reconstruction procedure we developed. The total flap size ranged from 20 × 13 cm to 30 × 15 cm. The length of the greater saphenous vein graft ranged from 4 to 11 cm. The hospitalization period ranged from 7 to 33 days. All of the flaps were viable, but in 1 patient, oral flap edge infection and necrosis necessitated partial debridement on day 7 postoperatively. All donor sites were closed primarily. We report our experience with this surgical method for complex reconstruction in advanced HNC patients.

Abbreviations: ALT = anterolateral thigh, CSF = cerebrospinal fluid, GSV = greater saphenous vein, HNC = head and neck cancer, LOFA = lateral circumflex femoral artery, MDT = multidisciplinary team, VLM = vastus lateralis muscle.

Keywords: advanced stage, anterolateral thigh, complex reconstruction, fascia lata flap, greater saphenous vein, head and neck cancer

1. Introduction
Head and neck cancer (HNC) refers to a series of malignancies comprising a variety of tumors that stem from the larynx, nasopharynx, oropharynx, hypopharynx, ear, lip, or oral cavity.[1] For advanced HNC, even with treatment with developing surgical, nonoperative, and comprehensive methods, the postoperative recurrence rate reaches up to 20% to 30%, with or without distant metastasis; however, the median survival time is only 6 months.[2] Surgery combined with radiation, chemotherapy, immunotherapy, and targeted therapy administered via a multidisciplinary team (MDT), which aims to control the symptoms or achieve limited metastasis resection to improve the quality of life of patients surviving with advanced HNC, has gained increasing acceptance. Advanced HNC often grows invasively and transregionally; consequently, a couple of adjacent structures, such as the orbit, oral cavity, pharynx, larynx, cervical vessels, and base of the skull, need to be resected simultaneously. While transferred tissue, such as a free flap with a vascular pedicle, is always needed to repair large defects following head and neck tumor resection, if the tissue is insufficient, direct suturing is impossible.[3]

An ideal flap suitable for head and neck reconstruction should be flexible for design (one or more flaps on 1 pedicle), adequate in tissue volume, have potential for reinervation (suitable blood vessel size and length), and be easy to dissect.[4] The anterolateral thigh (ALT) free flap, based on the lateral circumflex femoral vessels, has been accepted as an extremely versatile flap for composite soft tissue defects since Song et al.[5] first described it in 1984. As a universal flap, the ALT flap was popularized by surgeons for utilization in the reconstruction of defects in the head and neck.[6–8] The fasciae latae flap is commonly applied in reconstruction of the anterior skull base in endoscopic surgery.[9,10] The fascia lata flap can be used to successfully repair small defects (less than 10 mm) with 2-layer reconstruction, as well as larger skull base defects (larger than 20 mm) with a combination of fat or nasoseptal pedicled flaps.[11] In advanced HNC, extensive tumor resection can lead to large defects in the skull base and the leakage of cerebrospinal fluid (CSF). Nevertheless, the fasciae latae flap usually satisfies the need for the repair of large defects in the skull base.

Advanced HNC is always treated with radiotherapy and intra-arterial chemotherapy, which damage the local vessels to a certain extent. Therefore, surgeons face a challenge in that branches of the cervical vein or artery may be unhealthy and inadequate for anastomosis. Use of the greater saphenous vein (GSV) graft to prolong the free flap vessel is uncommon, having been reported in few cases.[12–14] When failure of the MDT model occurs in advanced HNC, salvage surgery could be used to resolve large and complex defects.
resulting from tumor resection. Joining the ALT flap with the fascia lata flap could provide a sufficient tissue volume for three-dimensional cranio-orbitofacial reconstruction. The GSV graft supplies adequate vessels for the flap, which could help eliminate the area limitation of free flaps. In this study, we applied a complex procedure (ALT/fascia lata flap with GSV graft) for the reconstruction of large defects in the head and neck region in 7 cases.

2. Patients and methods

2.1. Patients

The criteria for inclusion in the study were as follows: patients with large head and neck defects (greater than 20×10 cm), and inadequate vessels and skull base defects. All patients were treated with tumor excision and radiotherapy or chemotherapy before undergoing surgery in our department.

From June 2017 to January 2018, 7 patients with advanced HNC recurrence after MDT therapy underwent complex reconstruction following tumor resection using the ALT/fascia lata flap and GSV graft at the Department of Oto-Rhino-Laryngology of West China Hospital, Sichuan University, Chengdu, Sichuan. The study was approved by the ethics committee of the West China Hospital, Sichuan University. All tumor resection and reconstruction procedures were performed by the authors (C.F. and L.J.). The study data included demographics, flap size, skull base defect size, recipient vessels, harvest time, GSV length, and postoperative length of stay. In our study, wound infection, hemorrhage, CSF leak, and flap loss were considered complications.

2.2. Operative technique

Commonly, the lateral circumflex femoral artery (LCFA) gives off 3 branches after separating from the profunda femoris: the transverse branch, the oblique branch, and the descending branch. The descending branch always acts as a nutrient vessel for the ALT flap through septocutaneous or musculocutaneous perforators. Thus, color duplex ultrasonography or enhanced magnetic resonance imaging is needed to visualize the branches, especially the descending branch, of the LCFA despite the rare variation of absence (<1%). Our team prefers to apply a simultaneous 2-team approach during flap harvest in tumor resection. We always draw a line joining the anterior superior iliac spine and the superolateral patella, which corresponds to the septum between the vastus lateralis muscle (VLM) and the rectus femoris muscle. We also mark the midpoint of the line, where the skin vessels supplying the ALT flap are usually located. During the initial stage of flap harvest, a curved incision along the medial half of the line is made, followed by dissection through the subcutaneous fat to the fascia lata femoris. The fascia lata flap is then harvested to repair the skull base defect (Fig. 1). During dissection of the intermuscular

![Figure 1](image-url). (A) Harvest of the fascia lata flap (black arrow). (B and C) Suturing of the fascia lata flap to healthy soft tissue to repair the skull base (black arrows). (D) Harvest of the GSV graft (black arrow). (E and F) GSV graft bypass by vascular anastomosis with the facial and free flap pedicle arteries (black arrows). GSV = greater saphenous vein.
septum between the rectus femoris muscle and VLM, the descending and transverse branches of the LCFA are identified and preserved. The septocutaneous or musculocutaneous perforators are carefully verified and tracked to the main pedicle. A muscle flap from the VLM is also harvested to fill the dead space and strengthen the fascia lata around the cranial defect. The required size of the free myocutaneous flap is designed to be slightly larger than the tumor volume to ensure adequate tissue repair. The saphenous vein graft, worked as an overpass when the vascular pedicle is inadequate to reach recipient vessels, is harvested from the same incision of the myocutaneous flap (Fig. 1). The GSV graft can be anastomosed with both the artery and vein of the free flap or surgical field. When different surfaces in 3 dimensions need to be repaired, the ALT free flap is dissected into distinct skin paddles on the basis of separate vascular perforators (Fig. 2).[17,18]

3. Results

The patients enrolled in our study consisted of 1 female and 6 males, aged 33 to 78 years, with a mean age of 59.3 years (Table 1). The total flap size ranged from 20 × 13 cm to 30 × 15 cm, dissected into 1 or 2 skin paddles. The flap recipient vessels varied by patient and included the facial, transverse facial, lingual, and superior thyroid arteries. The recipient veins included the common facial, posterior facial, external jugular, internal jugular, and transverse cervical veins (Table 2). The hospitalization period ranged from 7 to 33 days. All of the flaps were viable, but in 1 patient, oral flap edge infection and necrosis

| Table 1 | Patient demographics. |
|---------|-----------------------|
| Items   | No. of patients (%)   |
| Mean age (yr) | 59.3 (33–78) |
| Sex     | 6 (85.71%) |
| Male    | 1 (14.29%) |
| Female  | 1 (14.29%) |
| Primary site | |
| Nasal sinus | 4 (57.16%) |
| Middle ear | 1 (14.28%) |
| Parotid gland | 1 (14.28%) |
| Orbital cavity | 1 (14.28%) |
| Pathology | |
| Adenocarcinoma | 1 (14.28%) |
| Adenoid cystic carcinoma | 2 (28.60%) |
| Squamous carcinoma | 1 (14.28%) |
| Sarcomatoid carcinoma | 1 (14.28%) |
| Fibroblastic carcinoma | 1 (14.28%) |
| Myofibrosarcoma | 1 (14.28%) |
The fascia lata flap was usually harvested when the deep fascia surrounding the tensor fasciae latae muscles was stripped. The fascia lata flap is sufficiently tough and dense to bear a certain degree of weight and pressure, and the fascia lata is considered to be the thickest fascia in the body. Both the fascia lata and dura mater consist of the same kind of biofilm. However, the fascia lata is thicker than dura mater and is composed of a large number of interwoven fibroblasts, forming a tough structure. The free tensor fascia lata flap survived with nutrition provided by the ascending and transverse branches of the LCFA.\[23]\] We repaired the skull base defect with the fascia lata flap, suturing it to dura mater and mucous membrane in the nasal cavity. On the one hand, this approach allowed the flap to be fixed in the right location and prevent CSF leakage; on the other hand, it facilitated the establishment of a blood supply and the healthy growth of the fascia lata flap. In all the patients in this study, dura mater defects were primarily sealed without complications such as CFS leakage or intracranial infection. Our experience demonstrates that the method applied for suturing of the fascia lata flap was effective and reliable for skull base defect repair.

The GSV is a superficial vessel between layers of dermis and muscular fascia; it is joined by several vascular branches and flows into the common femoral vein. There are several small perforating branches between the GSV and deep vein during the course of the vessel.\[24]\]

The GSV graft was first applied in heart disease for coronary artery bypass grafting in 1971. With the development of coronary artery bypass grafting, the left internal mammary artery and other vessels have been commonly adopted in clinical applications; however, the GSV graft also plays an important role as an alternative conduit.\[25]\] In our study, all patients underwent radiotherapy for advanced HNC, which resulted in short, unhealthy local vessels. During the process of harvesting the ALT flap, the GSV graft was harvested simultaneously. In our practice, the GSV graft was used to rescue the vessel shortage encountered during tumor excision in HNC patients previously treated with radiotherapy, without the occurrence of thrombosis or necrosis. Additionally, GSV bypass grafting was performed through vascular anastomosis with deficient recipient vessels involving various arteries, such as the facial, transverse facial, lingual, and superior thyroid arteries, and veins, including the common facial, posterior facial, external jugular, internal jugular, and transverse cervical veins. Chang et al\[26]\] reported that a 12-cm length of saphenous vein graft was used to prolong the pedicle of free flap, whereas we just harvested as long as 11-cm in our cases. Vascular diseases such as malformation (stenosis), varicose vessels, thrombosis, and idiopathic vasculitis were viewed as contraindications of GSV graft, which were not found in our cases. We used both vascular staple and microscopic suture in vessel graft and showed satisfactory effect. Skills such as appropriate suture density, vascular cavity patency, and heparinization are the key to the success of microvascular anastomosis.

The complex reconstruction method we performed is suitable for the surgical repair of large defects in the treatment of advanced or recurrent HNC along with comprehensive therapy. These patients shared some characteristics as follows:

1. tumor tissue infringed on a wide range of adjacent areas, including the skull base, resulting in complex defects;
2. neoplasm invasiveness and radiotherapy or other therapeutic methods gave rise to vessel damage and shortage; and
3. salvage surgery was the only option for these patients, who experienced the failure of comprehensive MDT therapy, such as chemoradiotherapy, targeted therapy, and immunotherapy.

For these patients, we preferred the complex reconstruction surgery consisting of the ALT/fascia lata flap and GSV graft because of the following reasons:

1. the complex flaps and GSV graft could be harvested simultaneously from 1 location;
2. the flap design could eliminate the vessel length limitation;
3. a sufficient quantity of tissue from the ALT flap could strengthen the skull base repair and eliminate the dead space without the insertion of a drainage tube;
4. 2 teams could simultaneously operate on the patient; and
5. the donor site could be primarily closed without a skin graft and with few complications.

It is a novel method and notion to combine ALT flap, fascia lata flap, and GSV graft as complex reconstruction after head and neck tumor resection. We acquired satisfactory result after 1 year follow-up, without complication in them. Parkes et al.[27] applied ALT flap in crani-o-orbitofacial reconstruction. Three cases of CSF leak were encountered, 2 of whom required reoperation using a vascularized nasal septal flap in 1 instance and a fat graft combined with a pericranial flap in the other. The main factor for the postoperative flap failure in their study was infection.[27] Hill and Rinker[28] documented that free flaps that have been utilized in reconstruction after orbital exenteration and cranectomy include the ALT flap and rectus abdominus myocutaneous flap; both achieved good therapeutic effect. However, the volume of muscle and skin of rectus abdominus myocutaneous flap was a little smaller than ALT flap in slim patient without enough physical exercise, hence we prefer the latter one. Meanwhile, the complex reconstruction method could solve the problem of large tissue defect, dura mater defect, and vessel shortage simultaneously, which could not be settled merely by traditional method such as pectoralis major musculocutaneous flap, etc.

Accordingly, there are some shortcomings or key points requiring attention regarding the complex reconstruction:

1. it is a heavy workload for a single surgeon;
2. some male patients have to deal with hair on the transferred flap; and
3. more samples and longer observation periods are needed to gain sufficient experience with this complex reconstruction procedure.

Overall, complex reconstruction with the ALT/fascia lata flap and GSV graft is optional and effective for salvage surgery in advanced HNC patients. Innovative microvascular free tissue transfer could meet the needs of reconstruction of various scopes and types. If we apply appropriate reconstruction methods, as reported in patients with advanced malignant tumors in the head and neck, more options will be available, and survival could be prolonged.

5. Conclusion

Complex reconstruction with the ALT/fascia lata flap and GSV graft could repair large defects after tumor resection for advanced HNC. The skills applied in patients with recurrent HNC after MDT treatment are feasible and of clinical significance. Infection of the complex flaps and donor sites was rare. There were no serious complications after the surgery. In clinical application, when a large compound defect occurs after resection for HNC, the composite reconstruction method described above could be used for repair.

Author contributions

Conceptualization: Fei Chen.
Data curation: Yu Xiang, Di Deng, Linke Li, Tengfei Ma.
Investigation: Tengfei Ma.
Methodology: Dan Lv, Haiyang Wang.
Resources: Jun Liu, Ji Wang.
Supervision: Shixi Liu, Fei Chen.
Writing – original draft: Weigang Gan.

References

[1] Lo Nigro C, Denaro N, Merlotti A, et al. Head and neck cancer: improving outcomes with a multidisciplinary approach. Cancer Manag Res 2017;9:363–71.
[2] Vermorken JB, Specsien P. Optimal treatment for recurrent/metastatic head and neck cancer. Ann Oncol 2010;21(Suppl 7):v253–61.
[3] Vartanian JG, Carvalho AL, Carvalho SM, et al. Pectoralis major and other myofascial/myocutaneous flaps in head and neck cancer reconstruction: experience with 437 cases at a single institution. Head Neck 2004;26:1018–23.
[4] Demirkan F, Chen HC, Wei FC, et al. The versatile anterolateral thigh flap: a musculocutaneous flap in disguise in head and neck reconstruction. Br J Plast Surg 2000;53:30–6.
[5] Song YG, Chen GZ, Song YL. The free thigh flap: a new free flap concept based on the septocutaneous artery. Br J Plast Surg 1984;37:149–59.
[6] Kimata Y, Uchiyama K, Ebihara S, et al. Versatility of the free anterolateral thigh flap for reconstruction of head and neck defects. Arch Otolaryngol Head Neck Surg 1997;123:1325–31.
[7] Koshima I. Free anterolateral thigh flap for reconstruction of head and neck defects following cancer ablation. Plast Reconstr Surg 2000;105:2358–60.
[8] Makite AA, Beasley NJ, Neligan PC, et al. Head and neck reconstruction with anterolateral thigh flap. Otolaryngol Head Neck Surg 2003;129:547–55.
[9] Wigand ME. Transnasal ethmoidectomy under endoscopic control. Rhinology 1981;19:7–15.
[10] Komotar RJ, Starke RM, Raper DM, et al. Endoscopic endonasal versus open repair of anterior skull base CSF leak, meningocele, and encephalocele: a systematic review of outcomes. J Neurol Surg A Cent Eur Neurosurg 2013;74:239–50.
[11] Bernal-Sprekelsen M, Rioja E, Ensenat J, et al. Management of anterior skull base defect depending on its size and location. Biomed Res Int 2014;2014:346873.
[12] Salibian AH, Tesoro VR, Wood DL. Staged transfer of a free microvascular latissimus dorsi myocutaneous flap using saphenous vein grafts. Plast Reconstr Surg 1983;71:543–7.
[13] Nahai F, Hageray R. One-stage microvascular transfer of a latissimus flap to the sacrum using vein grafts. Plast Reconstr Surg 1986;77:312–5.
[14] Earle AS, Feng LJ, Jordan RB. Long saphenous vein grafts as an aid to microsurgical reconstruction of the trunk. J Reconstr Microsurg 1990;6:163–9.
[15] Tursun R, Marwan H, Green JM, et al. Combined anterolateral thigh and tensor fasciae latae flaps: an option for reconstruction of large head and neck defects. J Oral Maxillofac Surg 2017;75:1743–51.
[16] Wong CH, Wei FC, Fu B, et al. Alternative vascular pedicle of the anterolateral thigh flap: the oblique branch of the lateral circumflex femoral artery. Plast Reconstr Surg 2009;123:571–7.
[17] Shiue SJ, Chiu HY, Yu JC, et al. Free anterolateral thigh flap for reconstruction of head and neck defects following cancer ablation. Plast Reconstr Surg 2000;105:2349–57.
[18] Yu P. Characteristics of the anterolateral thigh flap in a Western population and its application in head and neck reconstruction. Head Neck 2004;26:759–69.
[19] Yildirim S, Avci G, Akoz T. Soft-tissue reconstruction using a free anterolateral thigh flap: experience with 28 patients. Ann Plast Surg 2003;51:37–44.
[20] Park CW, Miles BA. The expanding role of the anterolateral thigh free flap in head and neck reconstruction. Curr Opin Otolaryngol Head Neck Surg 2011;19:263–8.
[21] Jiang C, Guo F, Li N, et al. Tripadded anterolateral thigh flap for simultaneous reconstruction of bilateral buccal defects after buccal cancer ablation and severe oral submucous fibrosis release: a case report. Microsurgery 2013;33:667–71.
[22] Cordova A, D’Arpa S, Jr Lorenzo S, et al. Prophylactic chimera anterolateral thigh/vastus lateralis flap: preventing complications in high-risk head and neck reconstruction. J Oral Maxillofac Surg 2014;72:1013–22.
[23] Koshima I, Urushibara K, Inagawa K, et al. Free tensor fasciae latae perforator flap for the reconstruction of defects in the extremities. Plast Reconstr Surg 2001;107:1759–65.
[24] Altshuler P, Welle NJ. Saphenous Vein Grafts. Treasure Island, FL: StatPearls; 2019.
[25] Sanchis-Gomar F, Perez-Quilis C, Leischik R, et al. Epidemiology of coronary heart disease and acute coronary syndrome. Ann Transl Med 2016;4:256.
[26] Chang KP, Lee HC, Lai CS, et al. Use of single saphenous interposition vein graft for primary arterial circuit and secondary recipient site in head and neck reconstruction: a case report. Head Neck 2007;29:412–5.
[27] Parkes WJ, Krein H, Heffelfinger R, et al. Use of the anterolateral thigh in cranio-orbitofacial reconstruction. Plast Surg Int 2011;2011:941742.
[28] Hill JL, Rinker B. Microsurgical reconstruction of large, locally advanced cutaneous malignancy of the head and neck. Int J Surg Oncol 2011;2011:415219.