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External jugular veno-accompanying artery adipofascial flap: an anatomic study and case series

바깥목정맥 동반 동맥을 혈관경으로 하는 지방근막 피판: 해부학적 연구 및 임상례

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박 성 오

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External jugular veno-accompanying artery adipofascial flap: an anatomic study and case series

by

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A thesis submitted to the Department of Medicine in partial fulfillment of the requirements for the Degree of Master of Science in Medicine (Department of Plastic and Reconstructive Surgery) at Seoul National University College of Medicine

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Abstract

External jugular veno-accompanying artery adipofascial flap: an anatomic study and case series

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Introduction: The veno-accompanying artery adipofascial (VAF) flap is nourished by accompanying vessels near large superficial veins. The authors examined whether the VAF flap can be applied to the external jugular vein.

Methods: Based on anatomic and angiographic studies, we performed reconstructive surgeries using external jugular veno-accompanying artery adipofascial (EJ-VAF) flaps. A retrospective chart review was performed for all patients who underwent this surgery.

Results: The presence of arteries accompanying the external jugular vein was confirmed. The presence of source arteries was also confirmed. These included the occipital, facial, and superior thyroid arteries. All

patients had satisfactory outcomes, except for 1 patient who had partial necrosis, which was managed using conservative treatment.

Conclusions: Our anatomic, angiographic studies and this clinical series indicate that the EJ-VAF flap is a reliable and convenient flap. Thus, it is useful in reconstruction of small to medium head and neck defects.

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K**eywords:** adipofascial flap, external jugular vein, veno-accompanying artery, veno-accompanying artery adipofascial (VAF), venoadipofascial flap

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Introduction

The veno-accompanying artery adipofascial flap (VAF flap) was first introduced by Nakajima et al. in 1998. (1) The flap is nourished by accompanying vessels near large superficial veins. The details of its arterial supply and venous drainage have been described in previous studies. Because it utilizes only superficial vessels and tissue, the VAF flap has many benefits. These include ease of raising the flap, convenience, and minimal donor site morbidity. (1-3)

However, VAF flaps have mostly been performed in the extremities, and their use in other regions is rare. (1, 2, 4) Until now, the use of the VAF flap in another region has only been reported by Kishi et al. in 2009, who confirmed the presence of an extensive arterial network near the external jugular vein. The authors also used the sternocleidomastoid muscle flap due to insufficient blood supply. (5)

We hypothesized that the external jugular veno-accompanying artery adipofascial flap (EJ-VAF flap) may be useful in covering small defects in head and neck regions. We performed detailed anatomical evaluations, including angiographic studies. We thus confirmed the presence of reliable pedicles near the jugular vein. Here we present a novel method of head and neck reconstruction using the VAF flap in the clinical setting.

Materials and Methods

We performed anatomic and angiographic studies, in addition to a retrospective chart review for all patients who underwent EJ-VAF flap reconstruction at our institution between 2011 and 2015. Electronic charts were audited for data including patient demographics, disease etiology, technical details of the operation, post-operative complications,

duration of follow-up, and clinical outcomes. This investigation was approved by the Institutional Review Board of Seoul National University Hospital (IRB No. 1605-047-760).

Anatomic and angiographic study

A lead oxide-gelatin mixture was injected into the arterial systems of two fresh cadavers, as described previously. (1) The skin and underlying soft tissue of the neck beneath the sternocleidomastoid muscle were elevated en masse. We then injected the external jugular vein with lead oxide to clarify its location. We hypothesized that the occipital artery, facial artery, and superior thyroid artery are the sources of the arteries accompanying the external jugular vein. We thus pre-marked their locations before the radiographic analysis. Each specimen was stereoscopically radiographed using a soft x-ray system (SOFTEX, Softec, Inc., Tokyo, Japan; 5 mA, 30 kVp, 30 seconds). We also performed radiography on the specimens after separating the sternocleidomastoid muscle, the platysma, and the great auricular nerve in order to clarify the locations of the arteries accompanying the external jugular vein.

Surgical Procedure

The external jugular vein was preoperatively marked using gentian violet. After measuring the size and shape of the defect, we designed the flap to have a width more than 1cm greater than the external jugular vein bilaterally. The pivot point was set 3 cm below the mandibular angle near the anterior border of the sternocleidomastoid muscle. The skin incision started at the caudal end of the flap and reached the deep cervical fascia. The exposed external jugular vein was ligated. Dissection was performed proximally just above the deep

cervical fascia. The external jugular vein and the adjacent adipofascial tissue were elevated. The elevated flap was insetted into the defect without any tension or pressure at the pivot point, and the donor site was closed (Figure 1).

Results

Anatomic and angiographic study

We were able to confirm the exact locations of the occipital, facial, and superior thyroid arteries from the deep side. These arteries were located adjacent to the external jugular vein (Figure 2, left). Further dissections showed the relationship between the sternocleidomastoid muscle and the external jugular vein. Consistent with previous studies, we found that the external jugular vein crosses the sternocleidomastoid muscle superficially (Figure 2, Right).

Angiography was used to visualize the detailed anatomy of the arteries of the neck. The arteries accompanying the external jugular vein were clearly observed after removing the sternocleidomastoid muscle. They communicated with the branches of the occipital, facial , and superior thyroid arteries, as expected (Figure 3).

The accompanying arteries were also intact after the separation of the platysma near the external jugular vein and the great auricular nerve (Figure 4). We further examined the influence of the platysma on the vascularity of the flap. We found that the arteries accompanying the external jugular vein remain intact in the absence of the whole platysma (Figure 5).

Surgery

We performed 13 head and neck reconstructions using the EJ-VAF flap in 13 patients. The mean age of patients was 61.7 years (range, 48 to 87 years). The mean follow-up period was 28.4 months (range, 15 to 50 months). The mean size of the flap was 6.7 x 5.8 cm. The maximal arc of rotation was 160 degrees. Primary closures of the donor sites were achieved in all but three patients, who underwent split-thickness skin grafts. Venous congestion occurred in three cases. In two cases, the congestion was resolved spontaneously within 3-4 days. However, in one case, venous congestion in the tip area was not resolved spontaneously and finally led to partial necrosis, which was managed with conservative treatment. Detailed patient information is presented in Table 1.

Case examples

Case 1

An 81-year-old woman was referred to our department due to a protruding mass in the right preauricular area. The mass was 5 x 4 cm in size. The biopsy report indicated that the mass was a keratoacanthoma (Figure 6, Left). A wide excision of the mass was performed with a 5-mm safety margin. The size of the resulting defect was 5 x 3.5 cm. A distally based EJ-VAF flap was designed around the right external jugular vein. The flap was elevated and included the adjacent adipofascial tissue under the platysma. The flap was inserted via a subcutaneous tunnel (Figure 7). The flap had survived without any noticeable complications throughout the follow-up period (Figure 6, right).

Case 2

A 52-year-old woman was admitted due to multiple trauma resulting from a traffic accident. There was a large defect involving the left mandibular area. The defect included significant bone loss. A free fibular flap with a skin paddle was initially created for the reconstruction. There were necrotic changes in the soft tissue, but the transplanted fibular bone was intact. A 10 x 7 cm defect remained after the debridement of devitalized tissue. We designed a distally based EJ-VAF flap around the left external jugular vein. We elevated the flap, which included the adjacent adipofascial tissue under the platysma. The flap was inserted with a 90-degree clockwise rotation. Meshed skin was grafted onto the donor site. The flap survived without any specific complications during the follow-up period (Figure 8).

Discussion

The existence of arteries accompanying cutaneous nerves was firmly established before the idea of arteries accompanying veins was proposed. The sural nerve is a representative cutaneous nerve with small arteries for its own nourishment. (6-9) One of the many researchers who contributed to finding accompanying arteries, Imanishi established the concepts of the neuroadipofascial (NAF) pedicled fasciocutaneous flap, the venoadipofascial (VAF) pedicled fasciocutaneous flap, and the veno-neuro adipofascial (V-NAF) pedicled fasciocutaneous flap based on detailed anatomic studies. (1, 2) The venoadipofascial pedicled fasciocutaneous flap was previously abbreviated as the VAF flap. However, during the era of perforator flaps, describing flaps based on their artery became more common. As a result, the VAF flap is now used as the abbreviation for the veno-accompanying-artery adipofascial flap. (4, 5)

The principle of the VAF flap was first described by Nakajima et al. in 1998. (1) Small arteries nourishing cutaneous veins are clearly observed in the deep adipofascial layer. This layer contains two kinds of vessels. One group of vessels forms an intrinsic venocutaneous vascular system, known as the vasa vasorum, which supplies the venous wall. There are no definite observable branches of this system in the skin. The other group of vessels forms an extrinsic venocutaneous vascular system, which runs along both sides of the vein within 10 mm of its wall. This system exists in the same layer as the cutaneous vein. Unlike the intrinsic venocutaneous vascular system, the extrinsic venocutaneous vascular system has obvious branches in the skin. (1) Studies of these systems indicate that the VAF flap is reliable for clinical use. (2)

Based on the results of previous studies and those of our anatomic and clinical investigations, we propose several principles for the use of the EJ-VAF flap. Considering the distance between the extrinsic venocutaneous vascular system and the venous wall, the minimum width of the flap should be 2 cm. In addition, the width of the flap should be determined considering the primary closure of the donor site, as this site forms a visible scar on the neck. The lower limit of the flap tip is the superior border of the clavicle because the external jugular vein proceeds at a deeper level just above the clavicle. The preservation of deep cervical fascia and soft tissue in the posterior triangle is mandatory for the protection of deep structures. The pivot point of the flap was set 3 cm caudal to the mandibular angle near the anterior border of the sternocleidomastoid muscle in order to preserve the branches of the occipital artery and the superior thyroid artery. Great care must be taken not to injure the great auricular nerve. The EJ-VAF flap can reach the lower temporal area superiorly, the chin anteriorly,

and the retroauricular area posteriorly. There should be no tension or compression pressure at the pivot point after flap transposition.

Various compositions of the EJ-VAF flap were examined. Angiography was conducted with and without the great auricular nerve and platysma, which are important adjacent structures. The presence of arteries accompanying cutaneous nerves has previously been demonstrated, and the great auricular nerve has its own accompanying vessels. The separation of the great auricular nerve did not affect the vascularity of the flap, and it did not alter the arteries accompanying the external jugular vein (Figure 4). It is unnecessary to scarify the great auricular nerve for flap elevation.

The platysma exists in a more superficial layer than the external jugular vein. The vascularity of the EJ-VAF flap may thus be affected following alterations to the platysma. However, according to a previous study, there is no intimate vascular system for the platysma. In this way, the platysma is different from other flat muscles, such as the latissimus dorsi, pectoralis major, and gluteus maximus, which have independent vascular supply systems. The arteries of the skin mainly originate from the deep adipofascial layer and penetrate the platysma. (10) Therefore, the platysma itself does not have a large effect on the vascularity of the EJ-VAF flap. As expected, we found that the arteries accompanying the external jugular vein were intact after separation of the platysma (Figure 5). Theoretically, the vascularity of the skin would be intact if only a 2-cm width of platysma just above the accompanying vessels of the external jugular vein is preserved in the skin paddle area. The platysma in the adipofascial pedicle area of the island flap can be removed without any vascular compromise. Nevertheless, we do not recommend separating the platysma from the flap. Dissection and removal of the platysma is a tedious,

time-consuming, and probably unnecessary process. The removal of the platysma may also cause potential damage to the vessel accompanying the external jugular vein and other vasculature in the flap. In addition, the flap elevation process is easier when the platysma is included. We therefore did not evaluate exact differences in vascularity of the skin between flap with and without the platysma.

Our clinical results indicate that the EJ-VAF flap is a reliable, convenient flap with promising vascularity for head and neck reconstruction. The EJ-VAF flap led to stable results even in complicated cases associated with infection after a severe trauma, although the number of these cases was small.

All of our EJ-VAF flaps were distally based flaps. However, they could also be used as proximally based flaps. Angiography indicated that a branch of the suprascapular artery communicated with the arteries accompanying the external jugular vein. Use of a proximally based flap had the potential risk of the loss of many of the source arteries, such as the branches of the occipital, facial, and superior thyroid arteries. This may then lead to diminished vascularity of the flap. Further studies are necessary before proximally based EJ-VAF flaps are used clinically.

The majority of the cases described were reconstructions of medium to large cheek defects. Many types of local flaps have been used for cheek reconstruction. These include the local advancement flap, the rotation cheek flap, and the cervicofacial rotation advancement flap. (11-14) The EJ-VAF flap has some unique benefits when compared to previously known flaps. It uses soft tissue from the neck, while the majority of other flaps use facial tissue. This means that the EJ-VAF flap does not lead to additional scars on the face. Facial asymmetry and dysmorphic changes, such as ectropion, can thus be minimized.

The EJ-VAF flap has some limitations. First, it results in a scar at the donor site on the neck. We therefore recommend the use of this flap in the relatively elderly patients who have redundant soft tissue on the neck. Another shortcoming of the EJ-VAF flap is that it cannot be used in patients who require simultaneous neck dissection and those who have previously undergone neck dissection. This method is also unsuitable for the treatment of deep defects because it is a thin flap. As a result, relatively old patients with superficial head and neck defects who do not have neck dissection are good candidates of this flap.

Our study has several limitations. The exact mechanism of the venous drainage of the EJ-VAF flap was not clearly demonstrated in our anatomic study. The external jugular vein has valves similar to those in the cubital vein in the limbs. (15) As indicated in a previous study on the lesser saphenous vein, (3) we believe that the venae comitantes of the arteries accompanying the external jugular vein had many anastomoses with the external jugular vein and played a role in bypassing the valves. Our study included a relatively small number of cases. Further clinical investigation is therefore required to objectively evaluate the EJ-VAF flap.

Conclusion

Based on our anatomical and angiographic study and our clinical series, we report that the EJ-VAF flap is a reliable, convenient flap, and is useful in reconstruction of medium to large head and neck defects.

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Figure Legends

Figure 1. Illustration of the distally-based external jugular veno-accompanying artery flap (AV: accompanying vessel, eJV: External jugular vein)

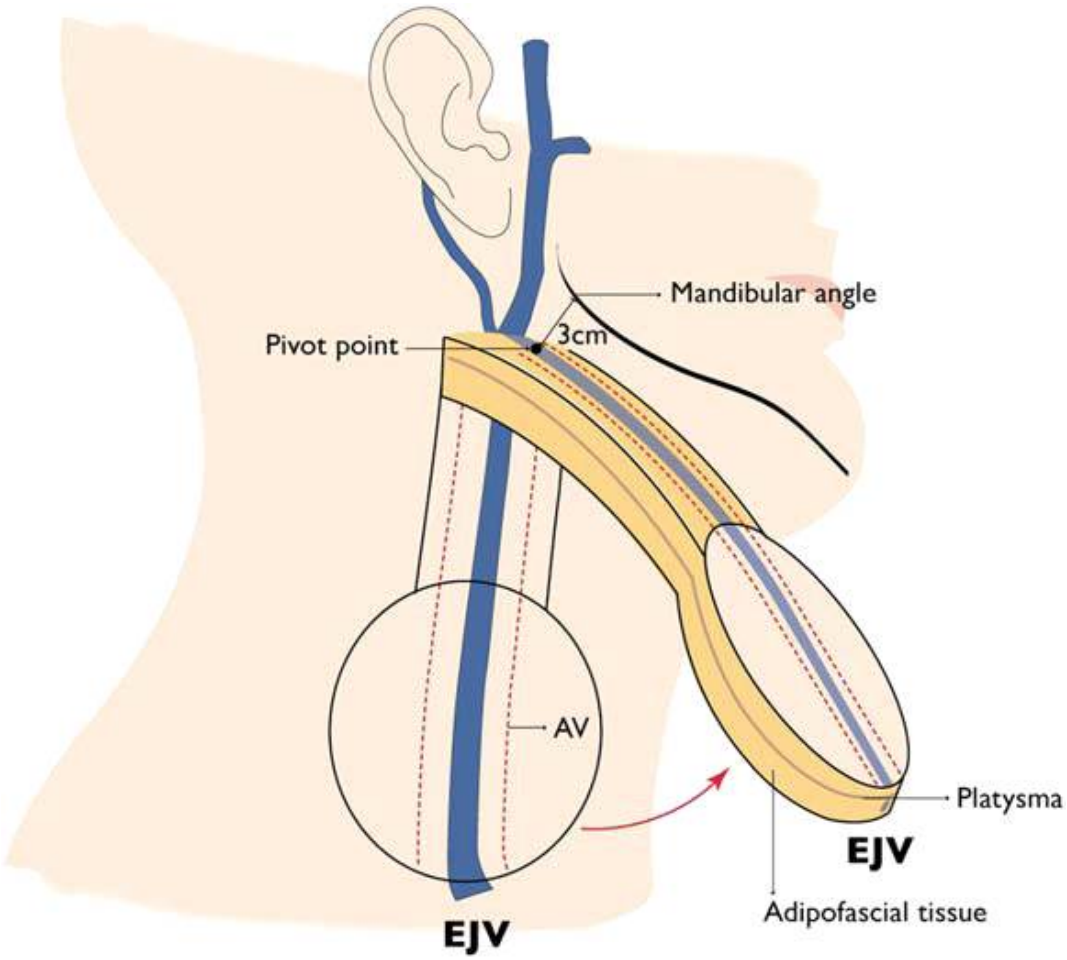

Figure 2. Image of the anatomic dissection. (Left) The sources of the artery accompanying the external jugular vein are mapped. The yellow arrow indicates the occipital artery, the red arrow indicates the facial artery, and the blue arrow indicates the superior thyroid artery. (Right) The relationship between the sternocleidomastoid muscle and the external jugular vein is shown. (SCM: sternocleidomastoid muscle, EJV: external jugular
vein)

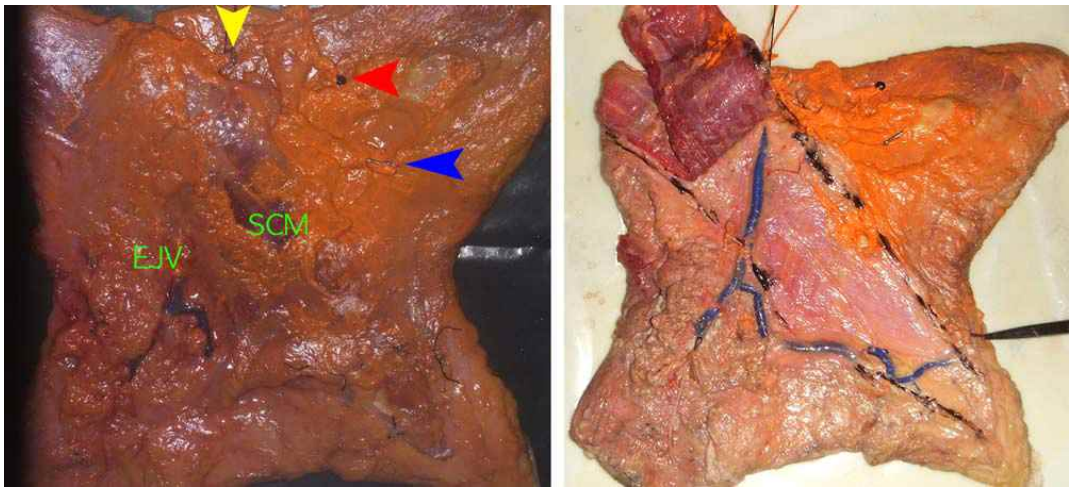

Figure 3. Angiographic image of the neck soft tissue after removal of the sternocleidomastoid muscle. (Left) The arteries accompanying the external jugular vein are shown clearly. The yellow arrow indicates the occipital artery, the red arrow indicates the facial artery, and the blue arrow indicates the superior thyroid artery. (Right) Magnified image of the area near the external jugular vein. (EJV: external jugular vein)

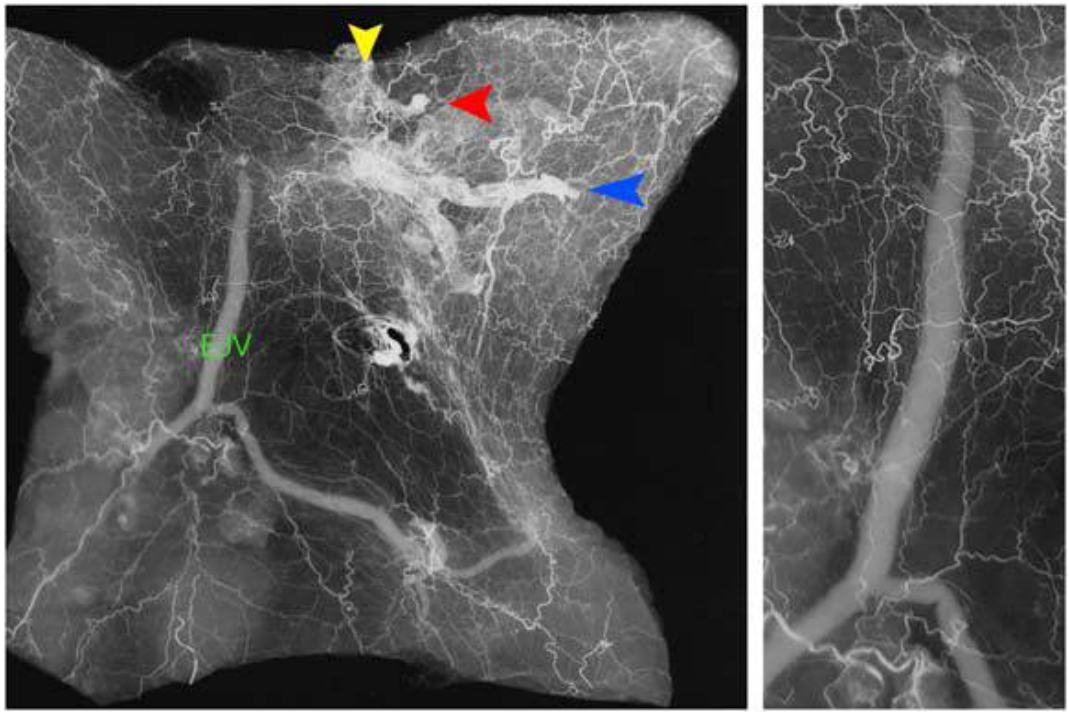

Figure 4. Angiographic image after the separation of the platysma and great auricular nerve. (Left) The platysma and great auricular nerve are separated. (Right) Magnified image of the area near the external jugular vein and the intact accompanying vessels.

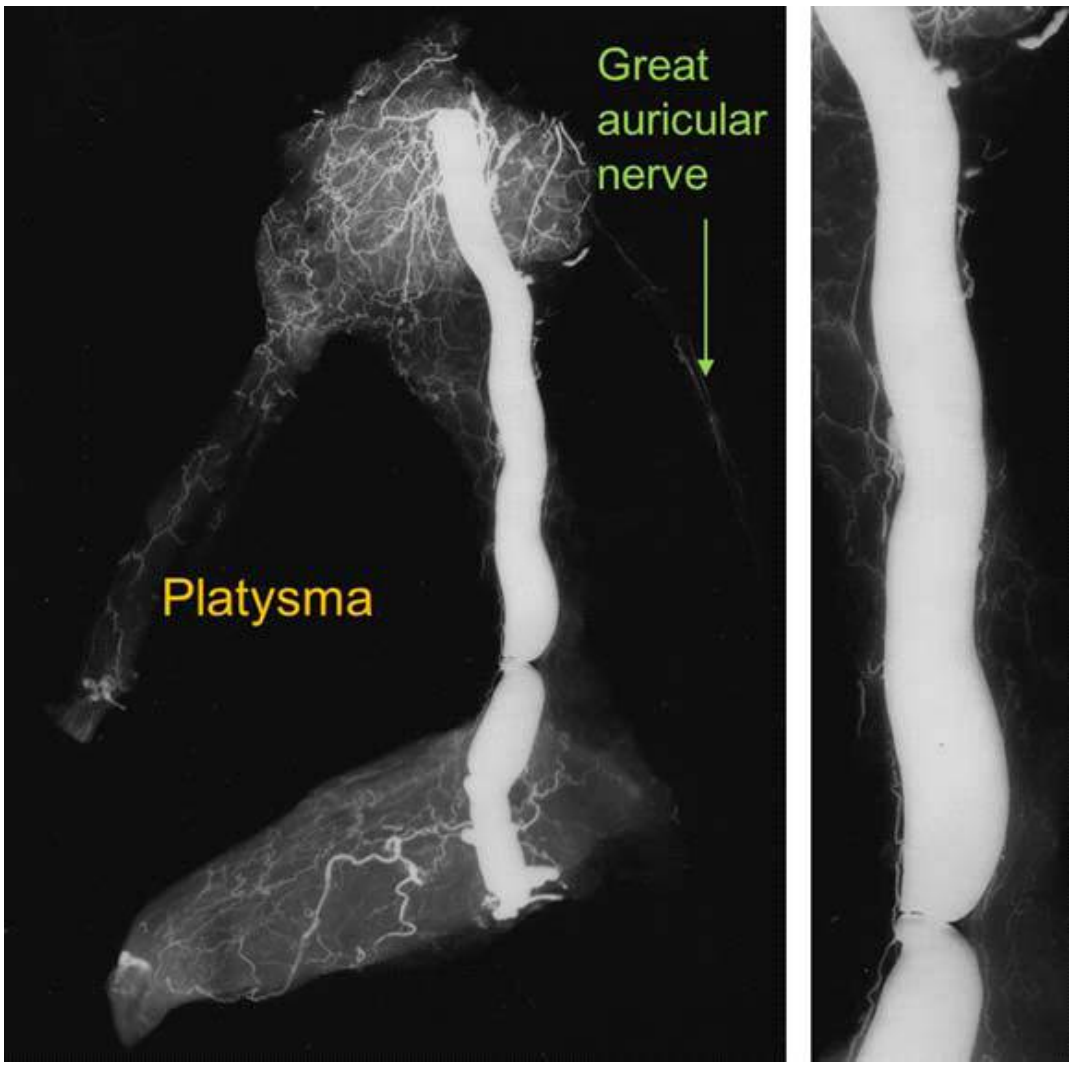

Figure 5. The role of the platysma. The accompanying vessels are intact after separation of the platysma. (Left) Angiographic image with the platysma. (Right) Angiographic image without the platysma.

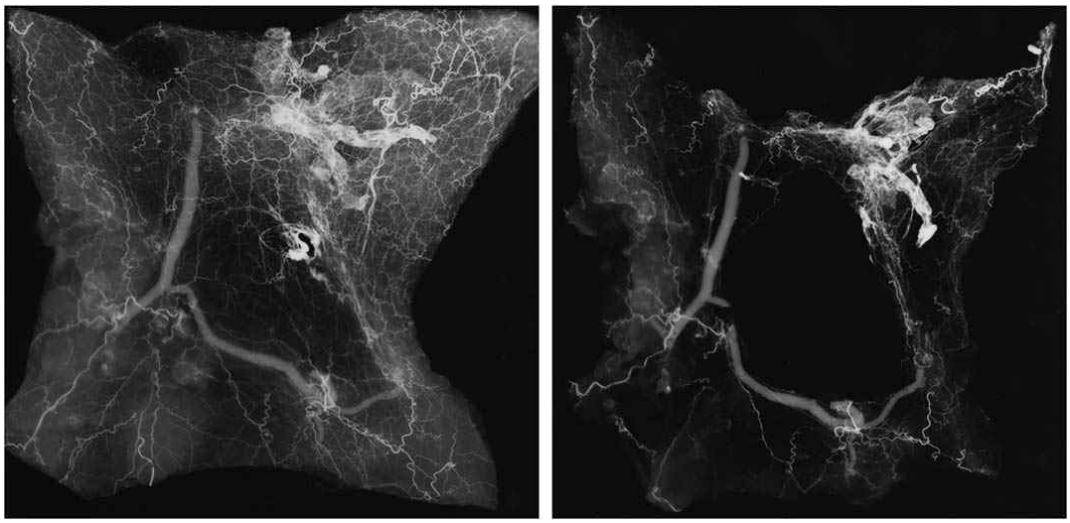

Figure 6. Preoperative and postoperative photographs of case 1. (Left) The patient was referred to our department due to a protruding mass in the preauricular area. (Right) Postoperative photograph after one year indicates good results.

Figure 7. Intraoperative photograph of case 1. (Left) An oval-shaped 4 x 6-cm defect remained after tumor removal. An EJ-VAF flap was designed as shown. (Middle) The elevated external jugular veno-accompanying artery flap. The flap contained adipofascial tissue adjacent to the external jugular vein. (Right)The EJ-VAF flap was transferred to the defect area via a subcutaneous tunnel.

Figure 8. Intraoperative and postoperative photographs of case 2. (Left) A 10 x 7-cm defect remained after debridement of devitalized tissue. An EJ-VAF flap was designed as indicated. (Right) Postoperative photograph after 4 months indicated good results.

Table Legends

Table 1. Patient information

Case	Age	Sex	Cause of defect	Flap size, cm	Flap type	Primary surgery or secondary surgery	Rotation degree[a], °	Donor site closure	Follow-up, mo	Complications
1	87	F	Tumor	5×4	Island	1	155	Primary closure	36	-
2	52	F	Trauma	10×7	Transposition	2	90	Skin graft	44	-
3	48	F	Tumor	8×6	Island	1	150	Primary closure	23	-
4	63	M	Tumor	9×6	Transposition	1	115	Primary closure	27	Partial necrosis
5	57	F	Tumor	7×5	Island	1	150	Primary closure	31	-
6	76	F	Tumor	7×6.5	Island	1	150	Primary closure	26	-
7	64	M	Trauma	9×6.5	Transposition	1	90	Skin graft	20	-
8	64	M	Tumor	6×6	Island	1	145	Primary closure	17	-
9	49	F	Tumor	4×5	Island	1	160	Primary closure	11	-
10	55	M	Tumor	5×5	Island	1	140	Primary closure	9	-
11	57	F	Tumor	3×7	Island	1	155	Primary closure	18	-
12	62	F	Tumor	7×6	Island	1	145	Primary closure	13	-
13	68	M	Trauma	8×7	Transposition	2	100	Skin graft	16	-

[a]Degree of rotation of the flap from its original position.

국문초록

서론: 정맥-동반동맥을 혈관경으로 하는 지방근막 피판은 큰 얕은 정맥에 동반하는 혈관들로부터 혈류를 공급받는다. 본 연구자는 이러한 피판이 바깥목정맥에도 적용 가능한지 연구해보았다.

방법: 해부학적인 연구와 혈관조영술의 결과를 바탕으로, 연구자는 바깥목정맥-동반동맥을 혈관경으로 하는 지방근막피판을 이용하여 재건수술을 시행하였다. 후향적 분석을 통해 본 수술을 받은 환자들을 분석해보았다.

결과: 해부학적 연구와 혈관조영술을 통해 바깥목정맥의 동반동맥의 존재를 확인하였다. 또한 동반동맥의 원천이 되는 동맥이 후두동맥, 안면동맥, 상갑상샘동맥임을 확인하였다. 부분괴사가 있었던 한명의 환자를 제외하고 모든 환자에서 만족스러운 결과가 있었으며, 한명의 환자는 보존적인 치료로 회복되었다.

결론: 연구자의 해부학적인연구, 혈관조영술, 임상증례들은 바깥목정맥-동반동맥을 혈관경으로 하는 지방근막피판이 신뢰성있고, 편리한 피판임을 보여주었다. 따라서 이것은 중소 두경부 결손의 재건에 유용할 것이다.

주요어: 지방근막 피판, 바깥목정맥, 정맥-동반동맥, 정맥-동반동맥 지방근막, 정맥지방근막 피판

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